Postharvest Food Losses in Sri Lanka

REPORT OF A WORKSHOP
11-16 FEBRUARY 1980

National Science Council

POSTHARVEST FOOD LOSSES IN SRI LANKA

Report of a Workshop held 11 - 16 February 1980

Cosponsors:

National Science Council of Sri Lanka
Colombo, Sri Lanka

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Colombo, Sri Lanka

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PREFACE

This is a report of a workshop on postharvest food losses in Colombo, Sri Lanka. The workshop, held February 11-16, 1980, was sponsored by the National Science Council of Sri Lanka, the U.S. National Academy of Sciences-National Research Council (NAS/NRC), and Sri Lanka Foundation Institute. The broad objective was to make recommendations for reducing postharvest food losses in three general categories--food grains, perishables, and fish.

Reliable data on food losses in Sri Lanka are unavailable. It is known, however, that losses occur both in quantity and quality. Losses were not considered for meat, dairy foods, poultry, and plantation crops; preharvest losses, while extensive in some cases, were also outside the focus of this workshop. Nevertheless, the three categories discussed represent the major foods in the typical Sri Lankan diet. Further, Sri Lanka spends large amounts of foreign exchange importing food grains and fish, and reducing the losses would lessen the balance-of-payment deficits.

This publication is intended for policy makers, administrators, scientists, and technicians working to reduce postharvest food losses in the developing countries. Part A of this report contains recommendations by each of the joint NAS/NRC-Sri Lankan working groups for reducing losses. Some of the recommendations are general and may be applicable elsewhere. Others are unique to Sri Lanka because of the socioeconomic milieu in which losses occur. Part B contains the background reports prepared for the workshop.

Participation by the NAS/NRC was made possible by the Office of Science and Technology, Bureau for Development Support, U.S. Agency for International Development (AID) under contract AID/ta-C-1433.

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PART A - SUMMARY REPORT

INTRODUCTION

In June 1975, the U.S. National Academy of Sciences-National Research Council (NAS/NRC) and the National Science Council (NSC) of Sri Lanka jointly sponsored a workshop, "Natural Products for Sri Lanka's Future." The purpose of the workshop was to identify scientifically sound projects for exploiting natural products that could contribute to Sri Lanka's economic and scientific development.

The 1978 NAS/NRC publication, Postharvest Food Losses in Developing Countries, stimulated Sri Lankan interest in the topic. Discussions were held between the staff of the Board on Science and Technology for International Development (BOSTID) and the NSC on the desirability for a workshop to address the problems of postharvest food losses.

Dr. R.P. Jayewardene, Secretary General of the NSC, and the Sri Lanka Foundation Institute (SLFI) offered to host the workshop. The NSC formed a steering committee to organize the workshop and plan the field trips. Three ad hoc panels were appointed to prepare background reports on food grains, perishables, and fish. The SLFI provided meeting rooms and dormitory and dining facilities.

Field trips were designed to acquaint U.S. panelists with actual conditions in the food industry. Each working group had the opportunity to observe techniques, practices, and conditions ranging from harvest to retail sales.

The circumstances surrounding food grains are unique; production of rice, the principal grain consumed, has not met demand primarily because the rate of population growth outstripped the rate of production. With the agricultural expansion in the Mahaweli Development Scheme, this situation will soon improve. In fact, modest amounts for export are anticipated. However, at present, the paddy is adulterated, contaminated, and high in broken and shattered grains. This condition must be corrected to command fair prices on the world market. Enhancing quality provides the added benefit of reducing losses. It is important, therefore, to initiate programs designed to minimize food loss and optimize quality improvement. Wheat is the other major food grain consumed. Although wheat is not grown in Sri Lanka, the demand for it grew out of exposure to the Allied armies' bread and flour products in World War II. Since large amounts of foreign exchange are spent on importing wheat, the government is

examining ways to reduce the demand. The workshop did not consider ways to reduce losses of imported wheat, but it did recommend that a review of this industry be initiated.

Postharvest losses of perishables present very different problems from those of food grains. Briefly, the soft nature of fruits and vegetables, high water content, and high rate of respiration contribute to losses typically ranging from 35 to 50 percent and frequently as high as 100 percent. Bruising is the major factor causing rotting (physiological and fungal), although insects, rodents, and birds also amplify losses. Special handling procedures, techniques, and equipment are required if losses are to be reduced. Most mature produce, even under the best of conditions, must be consumed within a few days of harvest. Proper transportation and appropriate equipment for handling produce are, therefore, essential. Although production facilities are generally near population centers where roads and trucks are available, this is not always the case.

The food-processing industry in Sri Lanka is small and handles less than 5 percent of the total produce. Fruit and vegetable production is seasonal, and the absence of an extensive processing industry means that food losses are high during periods of glut. The demand for processed food is less than for fresh produce and the cost is generally higher. Processing of perishables was not discussed during this workshop, but a separate review should be considered to determine how food losses could be reduced and, in the absence of local demand for processed foods, how this industry might add to foreign exchange earnings.

Food grains, fruits, vegetables, roots, and tubers (harvested and otherwise) are living, respiring tissues, with the proteolytic enzymes generally inactive. However, in fish the enzymatic decomposition process begins shortly after they are caught. Chilling the fish retards decomposition and should be done routinely. Unfortunately, ice is unavailable in many areas where fishing occurs. Fishing is done around the entire coastline, and the transportation system (roads, trucks, equipment) does not reach all areas. The demand for fish exceeds the supply, with people even willing to buy fish that would normally be rejected. This limits losses but has potentially deleterious health consequences and is aesthetically unappealing. However, the nutritional quality of mildly decomposed fish remains about the same as for fresh fish.

While a number of scientists and government departments in Sri Lanka have been working on various aspects of postharvest food losses, an overall review has not been conducted. Food losses occur throughout the farm-to-market system and cannot be eliminated entirely. In the United States, the single largest industry is the food industry and considerable effort has gone into minimizing losses. It was in this context that the NAS/NRC was asked for assistance and cooperation.

AGENDA, PARTICIPANTS, AND WORKING GROUPS

AGENDA

Monday, 11 February 1980

9:00 a.m. - Registration of Participants

9:30 a.m. - Address of Welcome
Dr. D. Wesumperuma,
Director, Sri Lanka Foundation Institute

9:40 a.m. - Inauguration
The Honorable S. B. Herath,
Minister of Food and Cooperatives

10:00 a.m. - Keynote Address
Mr. R. Wijeratne,
Secretary, Ministry of Agricultural
Development and Research

10:30 a.m. Tea

11:00 a.m. - Plenary Session for Review of Background Papers
and Formation of Working Groups

Chairman, Dr. C. R. Panabokke,
Director of Agriculture

12:30 Lunch

2:00 p.m. - Field Trips: Fisheries Station in Mattakkuliya;
Wholesale and Retail Vegetable Markets
in Narahenpita

7:00 p.m. - Film Show

Tuesday, 12 February, 1980

6:00 a.m. - Leave Colombo for Anuradhapura

Visit: Dessicated Coconut and Oil Mills;
Fishery Harbour;
Vegetable and Fruit Collecting Centers;
Paddy Collecting Centers;
Rice Processing Centers

7:00 p.m. - Anuradhapura - Night Stop

Wednesday, 13 February, 1980

6:00 a.m. - Leave Anuradhapura for Kandy

Visit: Paddy Collecting Centers;
Paddy Storage Centers;
Traditional Village Paddy Storage Methods;
Vegetable Collecting Centers

Afternoon Open

6:30 p.m. - Discussion of the Field Trips and Visits
8:30 p.m.

Kandy - Night Stop

Thursday, 14 February 1980

6:00 a.m. - Return to Colombo
10:00 a.m.

11:00 a.m. Working Lunch
12:00 noon

1:00 p.m. - Working Group Discussions
5:00 p.m.

7:00 p.m. Reception

Friday, 15 February, 1980

9:00 a.m. - Working Group Discussions

12:00 noon Lunch

1:30 p.m. - Preparation of Final Report

7:00 p.m. Reception

Saturday, 16 February, 1980

Morning - Closing Session

- Adoption of Final Report

Chairman, Dr. C. R. Panabokke,
Director of Agriculture

Co-chairman, Dr. Charles F. Niven, Jr.
Director of Research, Research Center,
Del Monte Corporation

Noon - Adjournment

PARTICIPANTS

Sri Lankans

C.R. Panabokke, Director of Agriculture (Chairman)
L.A.C. Alles, Marga Institute
S. Bandara, University of Peradeniya
P. Bhuvanendran, Ministry of Fisheries
M.A. Buksh, Sri Lanka Cashew Corporation
L.L.S.S.K. de Silva, Ministry of Plan Implementation
M.A.T. de Silva, National Science Council (Program Coordinator)
Jayantha Fernando, Cooperative Wholesale Establishment
H.M.D.B. Herath, Ministry of Agricultural Development and Research
H.M.E. Herath, Department of Agriculture
S.G. Illangantileke, University of Peradeniya
K.M. Jayewardena, Institute of Fish Technology
E.E. JeyaRaj, Central Institute of Scientific and Industrial Research
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N.G. Punchihewa, Marketing Department
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P. de S. Ranasinghe, Paddy Marketing Board
S.W. Ranasinghe, Sri Lanka Foundation Institute (Program Coordinator)
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L.N. Thevaperuma, Marketing Federation
H.D. Weeraratne, Marketing Department
V.E.A. Wickramanayake, Resources Development Con. Ltd.
N. Wickramasinghe, Central Agricultural Research Institute
W. B. Wijeratne, Department of Agriculture
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Observers

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S. Etoh, Food and Agriculture Organization
R.G. Poulter, Tropical Products Institute (London)
O. Silva, U.S. Agency for International Development (Colombo) (Program Coordinator)
T. Wilson, U.S. Agency for International Development (Colombo)
H.D. Traylor, Department of Agricultural Economics, University of Louisiana, Baton Rouge, Louisiana

WORKING GROUPS

	Perishable Food Losses	Durable Food Losses	Fish Losses
Sri Lanka Panelists	1. Alles, L.A.C. 2. Bandara, S. 3. Herath, H.M.E. 4. JeyaRaj, E.E. 5. Mohandas, S. 6. Punchihewa, N.G. 7. Seneviratne, S.N. de S. 8. Weeraratne, B.D. 9. Wijeratne, W.B. 10. Wijeratne, W.S. 11. Kenanayake, K.	1. Buksh, M.A. 2. Herath, H.M.D.B. 3. Ilangantileke, S.G. 4. Perera, J.M.M. 5. Rajapakse, L.A. 6. Ranasinghe, P. de S. 7. Thevaperuma, L.N. 8. Wickremasinghe, N. 9. Wickremanayake, V.E.A. 10. Gooneratne, J.	1. Bhuvanendran, P. 2. De Silva, L.L.S.S.K. 3. Fernando, J. 4. Jayawardena, K.M. 5. Premaratne, I.G.
U.S. Panelists	1. Bourne, M. 2. Niven, C. 3. Younkin, S. 4. Singh, P.	1. Efferson, J. 2. Huysmans, A.A.C. 3. Singh, P.	1. Liston, J. 2. Singh, P.
Other Representatives		1. Agrawal, N.S. 2. Wilson, T. 3. Traylor, H.D.	1. Etoh, S. 2. Poulter, R.G.

REPORT OF WORKING GROUP ON PERISHABLE FOOD LOSSES

INTRODUCTION

Reducing postharvest food losses is part of Sri Lanka's national scientific and technological efforts and falls within the framework of the Science and Technology Policy statement enunciated by His Excellency, President J. R. Jayewardene in December 1978.

Postharvest loss reduction is a complex problem with technological, scientific, infrastructural, and socioeconomic elements requiring a multidisciplinary approach. The basic information gathered during field observations and provided in background documents should be supported by more comprehensive studies. These studies must then be translated into action.

When discussing perishables (i.e., foods derived from plant sources such as vegetables, fruits, and root crops) the working group was able to identify several important problems and to suggest possible solutions, taking into account the following elements:

1. The range of varieties of these commodities, which fall into three broad groups:

    - the up-country vegetables (such as carrots and cabbage);
    - the low-country produce, which includes almost all the varieties of fruit and many varieties of vegetables, particularly those derived from shifting or chena cultivation; and
    - the leafy vegetables from the suburban market gardens.

2. The seasons in which specific varieties are produced.

3. The existing marketing system.

4. The public transportation network.

5. The limited nature of the food-processing industry.

Special Characteristics of Horticultural Crops

Among fruits, vegetables, roots, and tubers, the causes of loss, the rate at which losses occur, and the activities needed to reduce losses are quite different than those for cereals and oilseeds. These differences are summarized in Table 1.

TABLE 1 Comparison of Horticultural Crops vs Cereals and Oilseeds

Horticultural Crops	Cereals and Oilseeds
High moisture content, typically 80 - 90%	Low moisture content, typically 10 - 20%
Large unit size, typically 5 grams to 5 kilograms	Small unit size, typically less than 1 gram
High to very high rate of respiration. Heat production is typically 0.5 - 10 megajoules/ton/day at 0°C and 5 - 70 megajoules/ton/day at 20°C	Very low rate of respiration with little heat generation. Heat production is typically 0.05 megajoule/ton/day for dry grain at 20°C
Soft texture, easily bruised	Hard texture
Perishable, natural shelf life is several days to several months	Stable, natural shelf life is several years
Losses usually caused by senescence, sprouting, rotting (bacteria, fungi), and bruising	Losses usually caused by molds, insects, and rodents
Losses in LDCs usually 15 - 50%	Losses in LDCs usually 10 - 20%

Reducing Losses in Horticultural Products

Because of their soft texture, horticultural products are easily bruised, rendering the product unsaleable. Breaking the skin or bruising the flesh releases protolitic enzymes, hastening decomposition and opening the way for bacteria and fungi that cause rotting. Therefore, all horticultural products should be handled gently to reduce losses due to bruising and rotting. Bruising is probably the major cause of losses in Sri Lanka.

On the other hand, cooling horticultural crops extends their storage life. Therefore, every effort should be made to keep the temperature as cool as practicable by natural or artificial means. Horticultural crops should always be shielded from direct sunlight because sunlight raises the temperature, accelerating decomposition.

Postharvest food losses increase proportionately as the time between harvest and consumption increases. Therefore, the interval between harvest and consumption should be as short as possible. Indications are that most produce generally reaches the market within one or two days of harvest, which is a positive feature of the horticultural supply line. This short time span allows good-quality produce to be provided at the lowest cost with a minimum of waste.

Other methods for reducing losses exist, but, for the most part, they are not widely applicable, or are expensive procedures that would greatly increase the cost. Processing by canning, freezing, or dehydration is an excellent method for reducing losses because it converts a perishable product into a stable form. Processing also enables surplus foods to be available during times other than the harvest. However, these methods should be adopted only after assessing the overall benefits and cost.

RECOMMENDATIONS

1. Collect reliable data on postharvest food losses.

Programs to reduce losses cannot be properly designed and implemented until the extent of the problems are known. This, of course, does not mean that all action is to be held in abeyance until sufficient data are available. Programs can and should be started. As data is generated, and with actual experience, the programs can be modified where appropriate.

Obtaining accurate information is a formidable task and will require special facilities, manpower, and training. However, care must be taken to ensure that the generation of data is not an end in itself, but a tool for the planners and scientists dealing with food losses.

2. Improve handling techniques and equipment and review the transportation system.

Since the major cause of losses among perishables is from bruising, a review of packing procedures, equipment, and practices might readily identify areas for reducing losses. Bruised produce can still be marketable and is edible if the interval between bruising and marketing is short. Therefore, the importance of timely transportation of fresh produce (bruised or otherwise) is self-evident and a review of the public transportation network (policies, equipment, and infrastructure) should be an element of the overall survey.

3. Provide appropriate incentives to growers to produce high-quality horticultural crops.

One way to achieve this would be to establish grade standards for a few of the more important crops. These standards should be developed jointly by public officials, growers, and sellers. A publicity campaign urging consumers to insist on high-quality produce will help ensure the quality of produce delivered. This, in turn, will translate into greater care and attention by the various elements within the food chain and the subsequent reduction of losses.

4. Strengthen institutions already engaged in problems relating to post-harvest losses (e.g., government departments, research institutes, and university faculties) with requisite facilities, equipment, training, technical literature, and staff to enable them to address the problems identified in the studies.

5. Improve liaison and coordination of activities at the various centers and utilize the specialized training facilities, both locally and abroad.

REPORT OF WORKING GROUP ON DURABLE FOOD LOSSES

Durable food products, including rice, wheat flour, pulses, coarse grains, and spices, represent over three-fourths of domestic food requirements. These foods, except for wheat flour, are produced domestically, although some commodities must be imported from time to time. These imports impose a serious drain on Sri Lanka's balance of payments. Major production plans are being developed to achieve self-sufficiency, although wheat flour will continue to be imported because Sri Lanka's climate is unsuitable for growing wheat.

Postharvest food losses, however, provide a major bottleneck to these plans. Therefore, a thorough evaluation of these losses is critical for determining appropriate technologies, practices, and policies for specific programs.

Areas of significant losses occur as follows:

1. Paddy:

    - Untimely harvesting, shattering, bird and rodent damage, and the effects of excessive sun and rain;
    - Bundling, with additional shattering and exposure to the elements;
    - Transportation and handling, with further shattering and contamination;
    - Threshing, where deterioration occurs in both quality and quantity;
    - Drying and storage, where improper field stacking results in quality and quantity losses;
    - Milling, including inefficient parboiling practices; and
    - High moisture deterioration and similar problems.

2. Coarse Grains, Grain Legumes, and Oil Products:

    - Harvesting practices; and
    - Storage practices on the farm and in marketing channels.

3. Food Losses off the Field:

- Paddy and rice losses in the Paddy Marketing Board's storage facilities;
- Food losses at the Food Department; and
- Food losses at the Cooperative Wholesale Establishment when importing, storing, and distributing.

Although the total extent of postharvest losses of durable food products is unknown, these losses are estimated to be significant. Reducing such losses may have as great an impact as--or greater than--implementing numerous crop improvement and variety development programs, many of which are now underway in Sri Lanka.

RECOMMENDATIONS

1. Review the existing flow of food grains from producer to consumer and the agencies involved.

The profusion of official agencies, most of them operating without clear directives and coordination, serves to confuse the entire procurement and distribution operation. In some cases there may be duplication and counterproductive competition. Agencies such as the Paddy Marketing Board, Food Department, Multipurpose Cooperative Societies, Marketing Federation, Department of Development Marketing, Cooperative Wholesale Establishment, the University Faculty of Agriculture, Department of Agriculture, Ceylon Institute of Scientific and Industrial Research, and others are involved, to varying degrees, in postharvest activities. At a minimum, these separate and diverse efforts should be reviewed and coordinated. One of the objectives of the review should be to consider the creation of an Institute of Postharvest Technology.

2. Survey and assess the losses for the different commodities and initiate programs where significant losses occur.

The degree of postharvest losses for durable grains is unknown. Although some estimates show substantial losses--as much as one-third the quantity initially produced--recent studies in selected agricultural communities have shown that, with time-honored, conventional practices, food losses are relatively small. With the introduction of new technologies, new varieties, new machinery, and new cultural practices, postharvest losses are likely to be higher than in traditional systems. Special care, therefore, must be taken to reduce potential losses inherent in those new systems.

3. Improve the quality of marketed grains.

Although qualitative changes are often omitted in assessing postharvest food losses, they are equally important to quantitative losses, especially where they effect changes in nutritive value. Incentives to stimulate farmers to produce and deliver better-quality paddy and other durable grains are essential.

These could include programs to stimulate on-farm storage of paddy and other grains. At present, there is a fixed price paid for each grain, regardless of when it is delivered and regardless of its quality. This so-called flat-price system does not encourage the producers to deliver high-quality grain and actually encourages adulteration. In order to develop effective farm storage facilities, farmers must have access to supplemental credit to repay debts and meet expenses until the grain is marketed. This would help alleviate the cash problems farmers face at harvest. The construction of on-farm storage buildings would help relieve the intense pressure on procurement agencies at harvest time and save storage costs as well. These credit incentives should provide variable payments for different qualities so that growers will be encouraged to produce high-quality foodstuff. Or, conversely, a penalty may be imposed for delivering low-quality and adulterated merchandise.

Since simple, easily understood and tested grades and standards are available elsewhere, they should be established for all principal commodities in Sri Lanka. The present lack of clearcut specifications for basic qualities related to prices results in quality losses. This might be alleviated by establishing uniform weights and measures, preferably by weight rather than volume. Simple equipment for testing moisture is available. The use of such tests, used in connection with grades and standards, will also greatly help reduce storage losses and quality deterioration. Adulteration checks are also desirable. The need to clean and wash rice several times before cooking, picking out impurities, results in losses as high as 10 percent. Adulterations, such as the presence of sand, water, sticks, and stones, are other qualitative losses that must be reduced. The farmer and the trader are business people; they will deliver whatever quality the market demands. If the market accepts grain with 5 percent sand in it, this they will deliver; if it requires and pays for only clean grain, this they also will deliver.

4. Evaluate the Rice Processing Developing Centre (RPDC).

Rice is Sri Lanka's single most important food item, and RPDC's role should be reviewed. The Centre is well equipped and has good supplementary facilities, but it is playing a minor role in reducing postharvest rice losses. The Centre's functions, ownership, and management, and training, extension, and research programs should be carefully examined. The RPDC might even be expanded to include the other major durable grains, or could serve as the basis of the Institute of Postharvest Technology suggested in Recommendation 1 above. Part of the physical plant of RPDC includes rice-milling equipment. Consideration should be given to converting the mill from a demonstration plant into an operational mill to make better use of the facilities and to provide training. Possibly the research equipment should be separated from the commercial unit and the research broadened to cover all grains as well as the field operations--threshing, transportation, handling, and pest control.

Only by using all available talent and resources can maximum efficiency be obtained.

5. Upgrade training programs for managers of procurement agencies, wholesale outlets, and retail stores. The lack of trained staff throughout the procurement and distribution system is a major factor contributing to higher-than-normal losses. This staff includes weighers, graders, accountants, warehouse and storage operators, gunny bag distributors, and truck drivers, as well as overall management. Training programs designed to minimize losses, and incentives in the form of promotions, higher salaries, and bonuses are essential.

6. Introduce selective mechanization to the food industry, with appropriate training and extension services.

Low-energy-type machinery, preferably locally produced, for operations such as threshing rice, shelling pulses, moisture testing, grading, cleaning grains, and product handling, are essential to optimize efficiency. These approaches have brought marked progress in other countries and should be considered for Sri Lanka. Since existing methods of harvesting, handling, and milling of paddy often result in substantial contamination, quality reduction, and losses, the application of new machinery offers bright promise.

Modern technology, properly used, can do much to alleviate the food deficit in Sri Lanka. However, locally produced equipment should be considered if and when possible. To stimulate this development, once effective and low-energy-use machinery has been identified, an education and promotion program for machinery manufacturers should be established; a manufacturer of motorcycles can soon become a manufacturer of threshing machines if given a little help.

REPORT OF WORKING GROUP ON FISH LOSSES

Fish constitute the principal source of animal protein in the Sri Lankan diet and are important in maintaining this diet at a nutritionally satisfactory level. Fish production, principally from coastal fisheries, is at an average rate of 154,000 tons per year. However, per capita consumption of fish has decreased in recent years, falling from 14.5 kg in 1972 to 11.5 kg in 1978. This was due to a reduction in imports from 85,000 tons to 15,000 tons. Sri Lanka's rapidly growing population was also a contributing factor in the declining per capita consumption. Roughly 75 percent of fish is consumed fresh, approximately 22 percent consumed dried, the remainder canned or smoked.

Daily coastal fishing is common along the coastline, using small boats that do not usually carry ice. Typically, their catch is small. Some fish are landed by deep water trawlers (about 2 percent) and an increasing quantity is derived from fresh water (about 10 percent). Fish are distributed through a complex series of middlemen, particularly in large towns. Retail sales of fish are generally through small fish stalls or via foot or bicycle peddlers. Food stores and local markets distribute dried fish.

Storage and processing methods on board the vessels and throughout the distribution chain are generally poor and unhygienic. Losses, due to spoilage and insect damage, occur at all stages. Losses of processed fish also occur in both domestically produced and imported dried fish because of improper processing, poor storage, and rough handling through the distribution chain. Another major fish loss occurs when prawn boats dump fish accidentally caught in their nets. Financial losses and product losses are also incurred when importing countries reject prawns because of poor quality or contamination.

The problems derive from inadequate understanding of the proper methods for handling raw and processed fish, shortage of technical personnel, the dispersed nature of the fishery industry, logistical problems, high tropical temperatures and humidity, and poor facilities.

POSTHARVEST LOSSES IN THE FISH INDUSTRY

Food Loss in Fresh Fish

The losses at harvesting can be attributed to catching methods, the type of fishing gear used, and the lag time between the catch and marketing. Extended entrapment of fish in gill nets causes physical damage to the fish, which become exhausted and die and spoil faster. Dumping fish caught during shrimping operations is also a major loss.

Improper handling on board and a lack of preservation techniques and equipment are important elements to consider when identifying reasons for food loss. The typical boats used to haul fish do not have the space to carry ice. The caught fish lie on the boat deck exposed to high temperature (30°C) and rapid enzymic spoilage commences.

The lack of normal fish-handling equipment at the landing sites, such as chilled storage and auctioning facilities, inadequate water and ice supplies, exacerbated by Sri Lanka's polluted beaches, increase the losses.

The initial sale of fish begins at the landing sites where the fish are improperly iced (if ice is even available) in dirty wooden fish boxes. Ice should be used from the moment of catch to the final retail sale. Unfortunately, this simple, effective preservation technique is not used to its full potential because of the high price and erratic supply of ice. Sometimes, the fish must be kept on the beach because transportation is not available or until a sufficient quantity of fish is available for transportation to markets. During this period, also, quality loss can occur.

Fish caught in different areas are transported to the wholesale fish market in Colombo where additional losses occur. For example, the lack of chlorinated water and chilled storage facilities, uncemented flooring, insufficient drainage facilities, and poor handling practices can reduce the quality of fish. In most marketplaces, fresh fish is simply displayed on metal, wooden, or cement tables and exposed to high temperature and flies. At the retail shops, fish spoilage occurs because of insufficient ice or sometimes no ice at all.

As mentioned above, discarded fish from the prawn processing industry can also be considered a loss.

Food Loss in Cured Fish

The dried fish industry supplies only about 10 percent of Sri Lanka's domestic requirements; imports make up the balance. The drying of fish takes place at the landing sites when there is either no available transportation, no ice for preservation, or there is a glut. Typically, smaller species of fish are dried. The fish are directly sun dried or salted and dried. During sun drying, contamination can occur because of flies and the sand of the polluted beaches. Birds and animals feeding on the exposed fish also contribute to the losses. Bad weather conditions (rain and high humidity) can also accelerate the rate of spoilage.

Fish having high moisture content are an ideal medium for red halophilic bacterial growth and varieties of fish high in fats frequently turn rancid, causing further consumer rejection. These varieties should be considered for fish meal. Salted, dried fish are brittle and break easily, and poor handling practices and bad packaging create measurable physical losses.

Smoking inland fish varieties (e.g., tilapia) is common. The method still followed is primitive and involves smoking fish over a wooden grid on an open fire, which may result in additional loss due to charring or burning.

Fish Loss in Imported Dried Fish

The primary factor for quality loss is poor processing techniques at the supplier's end. Insufficient cleaning before brining also results in poor quality.

Other factors in the loss of imported dried fish are:

- Inadequate drying (high residual moisture);
- Use of poor-quality salt;
- Processing and storing under unhygienic conditions; and
- High oil content, which causes rancidity.

Bad shipping conditions are a contributing factor in imported fish loss resulting from:

- Poor ventilation in the hatches;
- Overstacking in the holds;
- Contamination with harmful items due to improper storage; and
- Insufficient spacing of shipments, thereby causing delays in clearance.

Food losses occur in the Cooperative Wholesale Establishment because of improper handling, inadequate facilities, and logistical problems; for example:

- Excessive handling of fish during sorting and grading operations as every bag is cut open and examined;

- Improper stacking, causing poor ventilation;
- Poor ventilation in the stores, along with high temperature and high humidity; and
- Slow movement of less popular fish varieties, increasing the incidence of spoilage.

Losses also occur in Sri Lanka's retail sector because of poor storage conditions.

EXTENT OF THE PROBLEMS

There is virtually no data on the extent of postharvest loss in Sri Lanka's fishing industry. However, observation of current practices, within the rather limited scope of this working group's visit, extensive knowledge of the industry among Sri Lankan participants, and discussions with fish industry businessmen and government officials all point to several conclusions. There is little or no evidence of loss in the wet-fish trade between landing and distribution to the consumer. Major quality loss occurs, which undoubtedly causes financial loss and may have health implications, but all the fish and nearly all the fish scrap are utilized either directly for human food or for animal feed (fish meal). The quantity used as fish meal is almost insignificant in terms of the entire catch. Financial losses due to waste and spoilage of Rs. 332,000, 347,500, and 110,500 were reported by the Ceylon Fisheries Corporation in 1968, 1969, and 1970 respectively, when total fish values were quoted as approximately Rs. 8,500,000, 9,100,000 and 8,200,000 respectively.

The marketing system for fresh fish has a number of intrinsic factors for reducing losses. If fish is spoiling and difficult to sell at the producer (fisherman) level, it may be converted into dried fish, which then sells at a lower price. At wholesale and retail outlets, prices are progressively lowered as spoilage proceeds and there is always an economic section of the population that will buy when the price is right. Indigenous cooking practices enable consumption of spoiled fish by masking offensive flavors and odors and by applying sufficient heat to destroy most bacteria. This permits even those at the lowest income level to benefit from the high nutritional quality of fish protein, since eventually the price will drop to a level they can afford. Diversion of incipiently spoiled fish to drying and curing is a tolerable procedure, since it stops spoilage and produces a stable product that does not require refrigeration. The high cost and relative scarcity of ice makes this procedure necessary.

Losses in the shrimp industry caused by rejection of the product by importing countries are an occasional problem. However, real losses occur during harvesting, when smaller-sized boats catch shrimp but must discard the larger number of fish caught incidentally (often 5:1 or more fish to shrimp). Sometimes the incidental or by-catch is mostly small fish such as silverbelly, for which there is little market; they will be rejected even by the larger vessels or possibly landed for subsequent use as fish meal.

Postharvest losses in the cured-fish industry are significant and are particularly high in imported fish, the reasons for which have been discussed earlier. In the case of imported fish, the causes may lie with processing and shipping conditions in the countries of origin, making control difficult.

The major economic factor limiting postharvest loss at present is the inadequate supply of fish. Demand greatly exceeds supply and almost anything is sold in one form or another. The fish may be in an advanced state of decay (the price will reflect this), but this is rarely a basis for discarding fish.

RECOMMENDATIONS

1. Collect more reliable statistics on actual fish losses--from capture through retail sale.

Present conclusions are based merely on educated guesses. There is an urgent need to know the extent of physical loss and possibly nutritional loss.

2. Establish a program of education, training, and extension for fishery officers, fishermen, retailers, and consumers.

This could start with short courses for fishery officers in fish handling and spoilage prevention. The fishery officers could then undertake extension training of the other groups. A more comprehensive system could be evolved later.

3. Develop university-level training in fish technology and general fisheries science.

This would provide for quality control, inspection, and extension services by technically competent personnel.

4. Improve fish landing and marketing facilities.

This would provide ice, clean working conditions, and good water supplies at a number of centres in as many areas as possible.

5. Establish chill storage facilities at major ports and markets and provide freezing and cold storage facilities in selected areas.

This would enable rational marketing of fish and reduce spoilage.

6. Establish a commission to review practices in the industry, revise standards of fish identification, formulate codes of practice in simple form for use by all industry segments, and consider measures to improve quality.

This could provide a basis for industry-wide improvement of existing

handling practices. However, arbitrary quality standards that prohibit sale of low-quality fish should not be established before a mechanism to ensure adequate protein supply to low-income consumers is developed.

7. Support or continue to support research in the following areas:

- Improved packaging and containers;
- Use of underutilized species (i.e., silverbelly and tilapia);
- Utilization of prawn-processing waste;
- Improved drying techniques;
- Improved smoking techniques; and
- Better salting procedures.

8. Explore application of alternative energy sources and appropriate technology in handling and processing of fish.

The application of alternative energy sources such as energy from fish wastes and solar energy should be explored to improve the handling practices of fish. The derived energy would have applications in operating absorption refrigeration systems, use of evaporative cooling, and drying and smoking of fish.

9. Improve management of inland fisheries to avoid harvesting fish that are too large or too small and to assist in uniform supply.

To maintain a uniform supply of fish from inland fisheries (such as carp and tilapia), it is necessary to improve management, aquaculture, and harvesting practices. This would require assistance from Sri Lankan government agencies to limit erratic supply of fish from these sources and possibly include some regulation of harvest.

10. Reduce losses in cured and dried fish in the following areas:

a. Processing

- Recommend a code of practice for curing fish;
- Provide price incentives for high-quality cured fish;
- Introduce use of anti-oxidants in high-fat-content fish.

b. Shipping

- Educate shipping agents on handling and storage procedures;
- Design appropriate equipment for handling dried fish;
- Improve stacking procedures for increased air circulation;
- Clean and wash storage area and emphasize basic hygiene and sanitation.

c. Marketing

- Assess quality through random sampling;
- Improve stacking procedures for increased air circulation;
- Clean and wash storage area and emphasize basic hygiene and sanitation;
- Improve storage techniques;
- Initiate educational programs for retailers on shelf stability of product.

PART B - WORKSHOP PAPERS AND BACKGROUND MATERIALS

PERISHABLE FOOD PRODUCTS: FRUITS, VEGETABLES, AND ROOT CROPS

L.A.C. Alles, H.M.E. Herath, W.S. Wijeratne, and S. Mohandas

Perishable food products discussed in this paper are fruits, vegetables, and root crops. They are generally used almost exclusively as fresh food in Sri Lanka, with small quantities consumed as preserved products. This is due primarily to Sri Lanka's relatively small geographical area and hence the accessibility of the growing areas to the urban markets of the main cities, which are well distributed throughout the country. Fresh foods are also popular because of the fairly even climate--unaffected by extremes of winter and summer--which permits the cultivation of many varieties of these perishables in most regions.

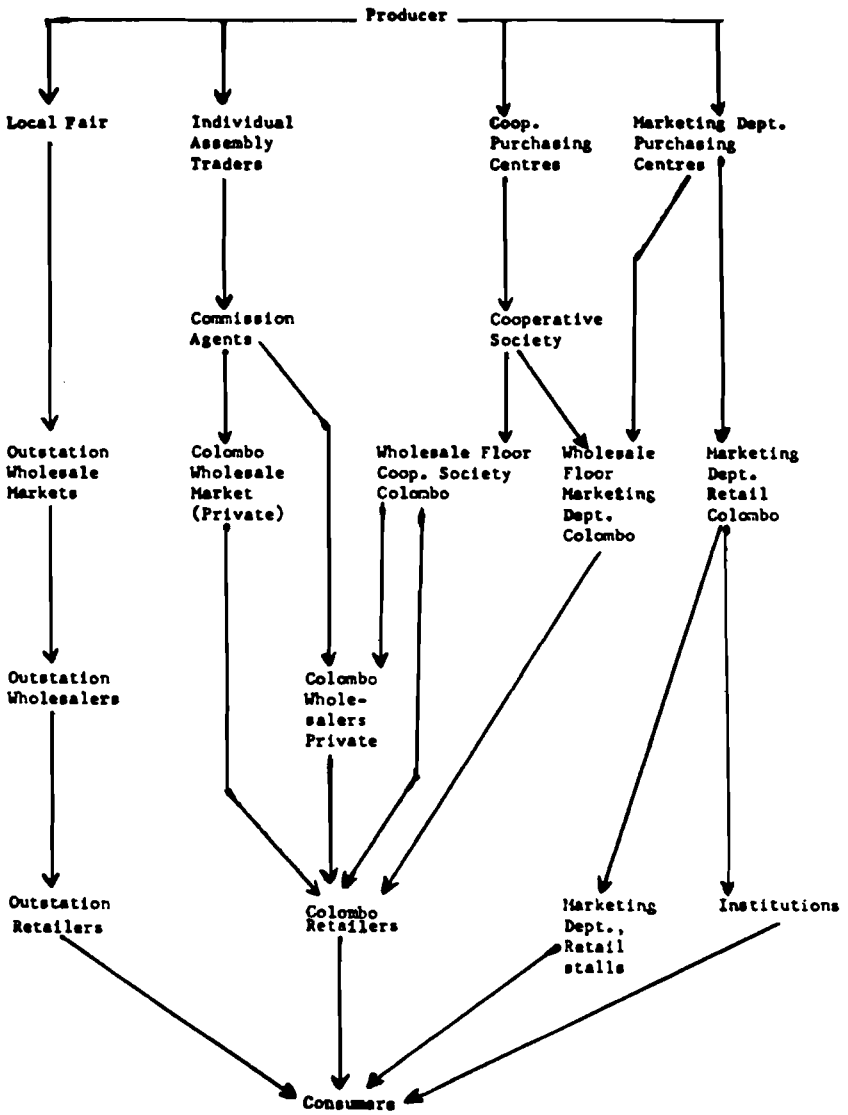
FACTORS AFFECTING POSTHARVEST LOSSES: GENERAL CONSIDERATIONS

As in the case of other food commodities, postharvest food losses in perishables also are influenced by several infrastructural factors; hence an appreciation of these factors is essential to understanding Sri Lanka's perishable food-loss problems. For example, the selection of planting material, whether it is imported seed or the farmer's own stock, the agricultural practices employed, including the use of agrochemicals and access to requisite agricultural know-how and credit facilities, are all determined by the economic status of the growers. Observations by this study team reveal that the higher-priced up-country vegetables usually demanded by the more affluent classes in the cities are grown in the hill country by the more prosperous farmers using intensive methods, selected seed, and appropriate agro inputs against diseases and pests. The cheaper chena varieties, on the other hand, are cultivated using more primitive methods, and these products must face greater competition in gaining access to the markets.

Similarly, when the harvest is high, the poorer farmer is unable to realize the full value of the crop because he is keen to realize some quick money to repay some agricultural debts, which he has invariably incurred. Also, pilferage is very common and he is unable to protect his crop against petty thieving. While these cannot be solved by science or technology, they are perhaps at least as important as the more tangible technical problems. Moreover, the need for postharvest storage facilities, even for a day or two, protecting produce from sun and rain, birds and other animals, and the need for basic necessities of packaging for road or rail transport are additional considerations that should be examined.

The effective utilization of agricultural produce with balanced benefits to both the primary producers, the agencies concerned with the collection and distribution, and finally the consumers, are all highly dependent on the existing marketing channels.

The main components in the fruit and vegetable marketing system are depicted below. It has been the government's primary objective over the last three decades to reduce the gap between the prices realized in the urban markets, such as Colombo, and those derived by the growers. This has been attempted by providing alternative nonprofit collecting and distribution systems(such as the Cooperatives and the Marketing Department, which are essentially government controlled), but their effect is yet confined to no more than 25 percent of the total volume of produce.



The growers of low-country chena vegetables--gourds, pumpkins, okra, eggplants, and lima beans--experience seasonal gluts and consequent price fluctuations, resulting in produce that cannot fetch an economic price and hence are a loss to the farmer. This is an area where a stable market, as provided by a processing and preservation industry, is extremely important. The finished products, being relatively cheap, could find a market both locally and abroad (e.g., the Middle East).

Growers of the up-country varieties of vegetables experienced different problems. Their producing areas are located 100-120 miles from Colombo, and the main form of produce transport is by lorry. Considerable losses, estimated between 5 and 35 percent, occur because of unsatisfactory packaging, lack of ventilation in the lorries, poor facilities for handling produce in the Colombo wholesale markets, and the extreme traffic congestion and inordinate delays before unloading. The most common form of packaging is in jute bags or gunnies, which, when packed tightly with vegetables, as is customary, and then stacked in lorries roof high, provide no ventilation. Self-heating and accumulation of respiratory gases and moisture cause the major losses, which are then aggravated by the hot humid conditions and direct sunlight characteristic of most retail vegetable stalls in the city.

While preservation by dehydration, canning, or freezing has not been applied to vegetables on a commercial scale in this country, the highly seasonal nature of many varieties such as breadfruit and lima beans, combined with available lucrative export markets and the low cost of raw material and labor, can make such preservation ventures worthwhile.

VEGETABLES

Vegetables grown and consumed in Sri Lanka fall into two broad groups:

1. Up-country varieties, consisting of cabbage, beet root, carrots, leeks, and beans, grown in intensively farmed market gardens at high elevations (over 700 meters above sea level) with systematic agricultural inputs and selected, often imported, seeds.

2. Low-country varieties, consisting of gourds, pumpkins, melons, okra, and lima beans generally grown in the dry or intermediate zone, by relatively poor peasant farmers engaged in traditional patterns of shifting or chena cultivation.

To this must be added the produce of market gardens surrounding the main cities, chiefly Colombo, consisting mainly of several varieties of indigenous leafy vegetables, which are significant in terms of quality and nutrition. This category also includes all the root crops--potato, sweet potato, cassava, and several varieties of indigenous yams.

Estimates of production of low-country varieties are unavailable, although

some figures for the more important up-country varieties reaching the trade channels are given below.

Variety	Area (hectares)	Production (tons/year)
Cabbage	360	7,200
Beet root	210	3,400
Carrots	130	1,500
Leeks	90	1,755
Beans	180	1,700

FRUITS

The main varieties of fruit grown in Sri Lanka, approximate annual production and some relevant remarks on their utilization are given in the table below. As with vegetables, fruit cultivation has also been mainly for the fresh market. Only with passion fruit and pineapple has orchard-scale cultivation for processing been undertaken, and only with passion fruit have processed quantities exceeded fresh fruit consumption.

Bananas, or plantains, deserve considerable attention when discussing postharvest losses. First, in terms of production volume it ranks high along with jak and is enjoyed by rich and poor alike as a standard dessert. Bananas are harvested unripe, transported to the consuming centres, and artificially ripened by smoking before being sold. The bunches are cut off prematurely, before the individual fruits have developed to full size, because of the danger of pilferage and to withstand rough handling in transport. This effectively reduces maximum attainable weight and also eating quality. Second, bananas are transported, stacked horizontally on top of one another to the full internal height of the lorry, so that the lower layers are crushed and the severity of the crushing damage is revealed only when the fruits have ripened. Finally, ripening is done by the age-old method of smoking rather than by modern, improved methods using ethylene. The overall loss from these factors has not been assessed but would be on the order of 25 percent by weight. This can easily be measured and the effect of improvements demonstrated. The knowledge and technology on banana growing, harvesting, ripening, and marketing available from the South American and West Indian industries can benefit Sri Lanka considerably.

Jak is consumed at several stages of maturity and ripeness--first at the tender stage (when the fruit has attained only about one-sixth of its final size) as a curry (polos), and second in the mature but unripe stage for its starch food value as boiled jak, and finally in the ripe stage as a dessert.

Name	Botanical Classification	Production (tons/yr)	Remarks
Jak	Artocarpus integrifolia	632,000	Used as starchy vegetables unripe, and as fruit when ripe. Good timber.
Banana	Musa sapientum & Musa paradisiaca	586,000	No processing or exports.
Mango	Mangifera indica	528,000	Processing is done for four or five cultivars of good flavor.
Papaya	Carica papaya	72,000	Some regions produce for papain extraction.
Limes	Citrus aurantifolia	47,000	
Oranges	Citrus sinensis	58,000	Citrus except limes has deterioration due to diseases.
Pineapple	Ananas comosus	35,000	Two main cultivars.
Wood-apple	Ferolia elephantum	100,000	Jungle crop.
Beli	Aeglos marmelos	67,000	Sporadic cultivation.
Passion Fruit	Passiflora edulis	15,000	Cultivation after 1970 mainly for processing. Predominantly flavicarpa.
Avacado	Persea americana	6,000	
Mangosteen	Garcina mangostana	16,000	

Jak is one fruit available in sufficient quantity to form the main base for a preservation industry both for local use and for export. The use of timber from jak trees is an additional factor in its favor.

Postharvest losses in mango (the third most important crop in terms of volume of production) arise from two causes: 1) the fruit is sold by growers to the traders who harvest when they have a market and not necessarily when the fruit is ripe (in fact, the fruit may be either too ripe or not ripe enough); and 2) the methods of transport and packaging, using the ubiquitous gunny bag, result in bruising and overheating.

Preservation of mango by canning and use in chutney has been done for many years, but the total consumption in these industries is of the order of 2,000 tons of fresh fruit annually, which is less than 5 percent of the total production.

Wood-apple (Ferolia elephantum), a hard-skinned citroid fruit, is essentially a jungle crop from the dry zone, especially from the Hamboantota area. It is traditionally used with jaggery (palm sugar) and coconut milk as a base for a dessert. Although only a limited amount of fruit is harvested now, the volume of fruit that could easily be collected during the season is very large indeed. In a sense, therefore, it was a postharvest loss of a utilizable fruit that could not fetch a price until processing procedures were worked out and adopted on a factory scale. At present, approximately 2,000 tons of fruit are converted to jam and canned puree (cream). This example is cited as illustrative of the type of development that will generate both employment and income. Wood-apple could be further exploited for export.

The problems associated with tomato are totally different from those of wood-apple. In contrast to the wood-apple, tomatoes have a fragile physical structure. Further, they are short-term cultivated fruit where varietal or cultivar characteristics such as color, flavor, and total solids are overriding factors. In spite of the excellent demand for both the fresh fruit and for the processed product in all its forms (sauce, puree, jam, etc.), the supply does not meet the demand.

The total quantity of tomato consumed annually in its processed form is approximately 1,000 tons. Cultivation is concentrated in a few growing areas in the hill country and in Jaffna. Postharvest losses in tomato approach 30 percent, arising mainly from unsatisfactory packaging in transport and bad handling at the sales points. Sri Lanka has not adopted ventilated railway wagons for fruit and vegetable transport and there is considerable loss due to suffocation and high temperatures, especially when the journey is made during the day in the hot sun rather than at night.

Postharvest losses in papaya are similar in kind to that of tomato in the sense that both fruits are fragile and suitable crates are not employed in their transport. The internal cavity, irregular shape, and relatively higher pH makes papaya all the more vulnerable. Use of commercial preservation

methods is limited to the production of small quantities of jam, canned fruit, and puree, all of which account for no more than 200 tons of fruit annually.

Sri Lankan pineapple, in spite of the low volume of production relative to other varieties of fruit, has enjoyed a good reputation, chiefly because of its excellent flavor. There are two main varieties, the larger, juicy, smooth-leaved cayenne and the smaller, better-colored, rough-leaved Mauritius. The main cultivation is in the wet zone and within a radius of 30-40 miles of Colombo. Total production has remained more or less static over the last three decades at around 2,000 hectares yielding 35,000 tons of fruit, of which no more than 10 percent is canned or otherwise preserved.

Postharvest spoilage in pineapple is relatively small and is due to unsatisfactory transport and exposure of the fruit to the direct sun. However, if one looks at complete utilization of all parts of the fruit, especially in processing, a considerable fraction of the raw material which can be processed into edible products is not recovered. This is true of most varieties of fruit that are preserved and processed.

DURABLE FOOD PRODUCTS: GRAINS, GRAIN LEGUMES, AND OIL CROPS

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INTRODUCTION

Rising demand for food and agricultural products, pressured by high population growth, has led many Asian countries to focus national policies on increased production and self-sufficiency. The drive towards self-sufficiency has resulted in the improvement of grain-production technologies, contributing to higher yields in South and Southeast Asian countries. Improved varieties, fertilizers, plant protection, and water-control practices have accounted for the yield increases. Along with the high yields is an increase in the magnitude of losses throughout the postharvest handling operations. The high losses resulting from traditional postharvest operations nullify the full realization of the increased yields and reduce farmers' financial returns, diminishing their ability to become a viable part of a developing country's economy.

Sri Lanka at present could be classified as one of the many grain-deficient countries in the world. Its annual production of rice, the staple food of its 14,000,000 people was 1,100,000 tons in 1976, which represents about 60 percent of its total domestic requirements (Table 1). After rice, the most important foodgrain is wheat flour, the total requirement of which is imported (Table 2).

Production of coarse grains and legumes falls short of national requirements. Low production and marginal returns per hectare are characteristic of these crops grown under systems of shifting cultivation practiced by subsistence farmers in the dry zone of the country (Table 3).

The Mahaweli Ganga (River) Development Project envisions intensive production of 360,000 hectares of land, of which only 53,000 hectares are currently single cropped with rice. The introduction of irrigation facilities for existing as well as new agricultural land will make possible high-land cropping as well as double cropping of rice. Intensive cropping schedules with improved varieties and technological and cultural practices should provide significant increases in the production of rice, coarse grains, legumes, oil crops, and roots and tubers.

TABLE 1 Domestic Production and Rice Imports to Sri Lanka from 1973 - 1978

Year	Domestic Production* (in 1,000 Tons)	Imports (in 1,000 Tons)
1973	880.6	335
1974	1,075.1	297
1975	774.4	450
1976	840.5	419
1977	1,125.9	530
1978	1,100.0	-

*Source: Agricultural Statistical Information, Department of Agriculture, Statistical Unit.

TABLE 2 Wheat Flour Imports to Sri Lanka 1973 to 1977

Year	Imports* (in 1,000 Tons)
1973	365
1974	442
1975	455
1976	380
1977	524

*Source: Agricultural Statistical Information, Department of Agriculture, Statistical Unit.

TABLE 3 Area Under Cultivation and Production of Subsidiary Food Crops--1978 - 1980

	Area Under Cultivation (in Hectares)			Production (in 1,000 Cwts.)		
	1978	1979 (Targets)	1980 (Targets)	1978	1979 (Targets)	1980 (Targets)
Coarse Grains						
Maize	28,610	38,590	36,400	692.8	688.0	630.1
Sorghum	550	415	365	10.7	8.6	17.0
Red millet	17,665	23,750	20,700	287.5	312.8	263.6
Yellow millet	560	1,370	1,315	10.2	17.0	14.1
Legumes & Oil Crops						
Cowpea	28,600	30,020	38,600	443.1	384.2	601.1
Green gram	12,280	12,680	16,010	165.3	164.2	217.3
Black gram	14,050	12,350	11,950	170.1	147.6	156.6
Soya beans	1,920	2,540	3,170	56.5	59.6	71.0
Ground nuts	8,310	9,760	8,500	147.1	197.4	191.7
Gingely	16,950	25,380	30,100	190.7	296.8	460.9
Root & Tuber Crops						
Manioc	39,200	58,100	46,900	9,793.6	41,612.6	17,653.0
Sweet potatoes	8,815	14,610	13,000	1,608.2	9,026.8	2,342.5
Potatoes	2,620	6,300	5,890	588.0	2,147.1	1,642.9

Source: Ministry of Agriculture.

An upward trend in grain production is forecast by 1985, with the implementation of the following programs:

- The cropping systems program of the Agriculture Ministry, leading to maximum use of limited resources such as land and water;
- The Mahaweli development scheme, whereby 30-40 percent of the irrigable land will come under the subsidiary food crops; and
- The floor price scheme for several of these commodities in 1980 when the government organizations (such as the Agrarian Service Department, Paddy Marketing Board, or Marketing Federation) will procure the produce from the farmer, which should open the market price far below the floor price.

Inefficient postharvest production practices can, however, provide a major bottleneck in the increased production plans. An evaluation of postharvest losses is critical for determining the appropriate technologies for independent postharvest operations. Independent evaluations of the separate operations in the systems have been insufficient. Therefore, emphasis must be placed on the study of all postharvest operations as a system.

EXISTING POSTHARVEST TECHNOLOGY OF GRAIN PRODUCTS

The postharvest operations could actually be divided into two sections where losses tend to occur. Losses in the operations could occur both on the field as well as off the field where the losses are mainly from product processing, storage, and transportation.

Farm Level Technology

Rice

Rice is cultivated in all climatic zones: wet, intermediate, and dry. The zone demarcations are based on climate and geography. The dry zone may either be subject annually to the Northeast monsoon of the Maha season or both the Northeast and Southwest monsoon of the Yala season. The wet zone has the benefit of both monsoonal seasons, resulting in a constant annual rainfall. However, seasonal fluctuations in weather may determine the outcome of monsoonal patterns in the intermediate zone, which lies between the wet and dry zone. The intermediate zone, therefore, may exhibit characteristics of either zone within one year.

Specific varieties suited for each climatic zone have been developed by plant breeders. Irrigation facilities in some areas have brought about more uniformity in varieties, but a majority of farmers still grow varieties best suited to their particular conditions.

Cultural practices vary between climatic zones because of different sowing and transplanting times used for the numerous varieties. Postharvest

practices in the three zones are basically similar, with a few exceptions in the wet zone where harvesting and stacking are performed early to overcome the uncertainties of weather. Traditional methods are used in all postharvest operations of rice in Sri Lanka. Use of mechanical or improved technology is limited and mainly applied to the off-field situation.

Harvesting. Paddy is commonly harvested in Sri Lanka with the hand sickle; machine harvesting is limited and confined to large commercial farms. Harvesting consists of grasping a number of rice stalks in one hand and cutting near the base with the sickle held in the other hand. The stalks are generally cut from 10 to 15 cm above ground level and laid on the stubble in small bundles. Some 15-20 small hand bunches of cut stalk paddy are normally tied together with twine. The stalks are grouped into a bundle in such a way that the panicles remain in the center, while the cut ends of the stalk face outwards. This prevents excessive grain loss during transport. Bundling varies according to the type of labor used. Bundles may be made smaller for ease of handling by women and children. In a few areas a mat may be tied around the bundle to collect falling grain during transport. This practice is limited mainly to very small holdings. The cut bunches of stalk paddy are commonly left to dry in the field overnight. The bundles are then transported to the threshing floor.

Bundles are normally head carried, although bullock carts, tractors, or trailers may also be used, if available. Cart linings to prevent grain loss have been observed in certain cases, but are not common. The bundles may be temporarily stacked in the field during unfavorable rainy conditions when transport is hindered.

Threshing and Winnowing. Threshing floor ownership varies according to farm size and location. Farmers may share a threshing floor or may possess their own. A tarpaulin sheet may be used in larger fields to construct a temporary threshing floor, thereby reducing the transporting distance. Farmers not possessing their own threshing floors may have to transport the bundles a considerable distance. The transported bundles are normally stacked loosely on the threshing floor. During bad weather farmers may make large stacks about ten feet in height and five feet in diameter. Stack size varies with the experience of the people constructing them. Stacks are made as water-tight as possible to preserve the panicles for up to 2 years. The moisture conditions of the stalk and grain at stacking time determine the storability of the paddy. The stack function is twofold: 1) for storage of the stalk until favorable weather arrives; and 2) for holding until threshing can be done. Availability of labor, animals, machines, or tractors for threshing affects the time of threshing. Threshing-floor availability depends on the farm size and the economic conditions of the farmer. Small farmers may just place a jute or tarpaulin sheet over hard ground to serve as a threshing floor. In some cases threshing may be done directly on the rough, hard ground. Mud- or cement-plastered threshing floors are better but more expensive and are generally owned by farmers having a higher economic status.

Five methods of threshing are used in Sri Lanka:

- Manual treading;
- Animal treading;
- Tractor threshing;
- Pedal threshing; and
- Mechanical threshing.

Manual treading is practiced in wet-zone areas where farm sizes are extremely small. This method involves spreading the stalk paddy on a hard surface and then walking and trampling on them until the kernels are detached. For animal treading, the stalks are laid two or three sheaves deep in a circular pattern on a threshing floor. Paired buffaloes are then driven slowly around to trample out the grain. This is probably the most traditional practice in Sri Lanka and is used in the dry, intermediate, and wet zones. Many farmers who do not own buffaloes rent them.

Four-wheeled tractor threshing is sometimes used. It is more costly than the use of buffalo but is more convenient and increases the threshing rate. The tractor is run continuously in a circular path over stalk paddy laid on a threshing floor. Threshing by mechanical equipment has not found widespread acceptance primarily because of the limited size of the holdings and the high capital costs.

Paddy winnowing is done traditionally with a flat round rattan tray edged with a small lip. The paddy is tossed and shaken with a twist of the wrist to move the empty husks, light kernels, and chaff to the edge of the tray opposite the worker. The chaff and empties are thrown over the edge of the tray, which is then held above the head and shaken gently until the grain falls to the ground. The chaff and dust are carried away by the wind. This traditional method, although simple, requires considerable experience to perform. Mechanical fans are being introduced for winnowing. Bicycle-peddling mechanisms with a fan attached in place of the wheel can be manufactured by local blacksmiths. The pedals are turned by hand. Fans are also attached to the drive shaft of two-wheeled and four-wheeled tractors. Cleaning is fast and efficient but is not an energy-efficient operation. This method is, however, used on the larger holdings, especially in the dry zone.

Drying. Most farmers dry their crops in the field before harvest. If the weather is favorable, the crops are left in the field until uniform drying is achieved. Field drying, however, is very slow and often takes about 2 or 3 weeks after maturity. After the harvest the cut-stalk paddy is left on the fields or bunds for further drying, usually for a period of 8-24 hours. Some farmers may harvest at a higher moisture content and allow the stalk paddy to lie on the stubble longer. In either case, the grain is exposed to wet weather, early morning dew, insects, rodents, and birds.

The threshed grain is dried on various types of sun-drying floors as is done in many Asian countries. Mats, cemented floors, roadways, and household yards are some of the common places for sun drying. The kernels are spread evenly about 5-8 cm thick on the drying yard, and intermittently hand stirred

until the grain is dry. At night, or when rain or heavy dew occurs, the paddy is heaped and covered, then spread out again when conditions are favorable.

Storage. The farmers are usually in need of money and dispose of their crops at the earliest opportunity. They store sufficient quantities of paddy to provide food from one season to another as well as provide seed for the next cultivation. Usually about 30-50 percent of the total production is retained. Farm storage is therefore restricted to small storage structures, often built adjacent to the farmhouse. Storage structures are oval in shape, with a wide circular opening at the top. They are made of split bamboo sticks plastered with clay and lime, and supported by wood or stone pillars. Bag and bulk storage of paddy in small quantities may be practiced in farm households, but is a temporary measure prior to grain disposal at the market.

Coarse Grains

Maize, sorghum, and millets are grown essentially on a subsistence level; the present area under cultivation as well as the projected acreage for 1980 are represented in Table 3.

Traditional postharvest operations for coarse grains are the norm in Sri Lanka because the area under cultivation per individual family holding is small. Limited on-farm storage is carried out by the subsistence farmer. The traditional bissa is used in certain villages for grain and legumes storage essentially for domestic consumption and seed. Maize is traditionally stored on the cob. Since farmers prefer to dispose of their produce as fast as possible to obtain cash, the duration of farm storage for coarse grains is short, except for those used for domestic consumption.

Grain Legumes and Oil Crops

Pods of cowpea, green gram, and black gram are harvested by hand. The maturation rate of these crops varies, requiring numerous harvests. Black gram in certain districts is completely harvested and then threshed when almost 70 percent of the pods are mature. Seed removal from pods is done manually by beating the sack full of pods on the ground. The postharvest technology of these crops is traditional and studies have not been made to monitor the post-harvest losses of such grains.

Soybean production has increased in the recent past. Again the post-harvest technology is traditional, with a few exceptions limited to large farms. Soybeans are much easier to harvest than most other crops grown in Sri Lanka. Plants are cut, bundled, transported, and accumulated on a thresh-ing floor. The plants with pods are threshed either by hand or by running a tractor on a pile of soybean plants 3-4 feet deep. The threshing operation is similar to that used for rice.

Groundnuts and sesame are also harvested when the products are between 60 and 70 percent mature. The postharvest movement of such crops has not yet been studied in detail. The storage of the crop is again very traditional, with the farmers selling their produce in the market at their earliest convenience.

OFF-FARM-LEVEL TECHNOLOGY

Procurement, Processing, Storage, and Distribution of Grain and Food Products

The purchase, transport, and storage (with or without processing) of coarse grain, legumes, and oil crops are carried out by government agencies and the private sector. About 50 percent of the produce of sesame and maize is purchased by the state-owned Oils and Fats Corporation. Forty percent of the maize is consumed at the immature stage. About 50 percent of the soybean is purchased by the CARE organization, while the national organization for cooperative marketing (Markfed) does limited purchases of all commodities. Most grain and food products are handled by four government-sponsored organizations in Sri Lanka.

The Paddy Marketing Board

An Act of Parliament in March 1971 established the state-sponsored corporation, the Paddy Marketing Board (PMB), to handle the purchase, storage, and processing of paddy rice. The PMB's objectives are as follows:

- To do the purchasing, hulling, milling, processing, supplying, and distributing of paddy and rice;
- To carry out any other business incidental or conducive to attaining the first objective; and
- To perform duties that, in the opinion of the PMB, are necessary to facilitate the proper functioning of the business.

The PMB annually handles a bulk of paddy equivalent to about 24-32 million bushels (Table 4).

The PMB has shown marked efficiency in discharging the guaranteed price scheme (GPS) system and it demonstrates strong leadership in modernizing Sri Lanka's postharvest paddy industry.

The PMB has 12 regional offices in the 22 districts of the country, with 3,090 purchasing centers and plans for 1,000 more. It has 294 paddy stores in 160 locations, mainly in major rice-producing areas, with a storage capacity of almost 300,000 tons. The storage capacity for permanent bag storage consists of chambers ranging between 250 and 1,000 tons, 23,600 tons of bulk-type storage, and a 20,400-ton capacity for temporary storage in outdoor stacking under canvas or plastic sheets.

Table 4 PMB's Annual Purchase of Paddy

Year	Purchase (in bushels)
1975	11,579,000
1976	12,875,000
1977	24,555,000
1978	32,347,000

Source: PMB statistics

In addition to paddy, the PMB also purchases a number of subsidiary food crops such as maize, sorghum, black gram, soybeans, sesame, groundnuts, chillies, and tumeric.

Table 5 Purchase of Subsidiary Food Crops by the PMB (in Tons)

Crop	1975	1976	1977	1978
Maize	17,780	10,700	15,170	7,220
Sorghum	780	70	95	40
Soybeans	-	-	290	405
Black gram	-	-	5,175	6,590

Source: PMB Statistics

The PMB buys paddy with a moisture content of 15-17 percent. Natural drying brings moisture down to about 14 percent. Moisture levels less than 13 percent present milling problems. Pest attack in PMB stores is controlled by phosphine fumigation and by spraying or fogging with pirimiphos methyl.

In 1977 the PMB purchased 560,000 tons of paddy. It has a milling capacity of 180,000 tons per year, of which 125,000 tons are parboiled. The PMB operates in cooperation with private quota millers who have millery capacities of 550,000 tons per year. Rice, milled by the PMB and the quota millers, is turned over to the Food Department (FD) for distribution. Except for a few mills operated by the PMB, most of Sri Lanka's mills are obsolete. The PMB and quota millers milled approximately 35 percent of the paddy, while private millers, whose equipment is as obsolete, milled the balance.

The Flour Milling Corporation

The Sri Lanka Flour Milling Corporation imports 21,000 tons of wheat per month from Australia. These stocks are moved from the ships to the mill, located at the Colombo seaport. Milling is done there, and the flour extraction is 73 percent, with the balance being bran. The flour is bagged and distributed within about 2 days to cooperative stores or to the FD. Bran is generally exported, but if export orders are delayed, pest infestation results. Control is usually by fumigation with phosphine or bag spraying with pirimiphos methyl.

A second very modern flour mill, with a capacity of 50,000 tons per year commenced operations in 1979 as a private enterprise. The Sri Lanka Government imports the wheat and the mill produces the wheat flour for the government and exports the bran.

The Government Food Department

The Government Food Department (FD) is responsible for the import of rice and flour and is the storage and distributing agent for PMB processed rice as well as imported rice and flour.

In 1978 the FD handled 161,000 tons of imported rice, 253,000 tons of locally processed rice through the PMB, 605,000 tons of imported wheat flour, and 62,000 tons of locally milled wheat flour. It has a permanent storage capacity of 488,000 tons, more than half of which is associated with the Port of Colombo, and the rest in three major district centers.

Rice and flour are stored by the FD in jute bags, generally without dunnage in rectangular chambers, which are not bird- or rodent-proof. Storage capacity ranges between 250 and 1,000 tons. Turnover rate for rice and flour in these storage complexes averages around 3-5 months, but stocks of rice could occasionally exceed one year in storage.

The Cooperative Wholesale Establishment

The Cooperative Wholesale Establishment (CWE) is the largest importer and distributor of subsidiary food items. It also purchases a number of locally produced food items, the most important of which are:

- Pulses and cereal grain (e.g., split lentils and barley);
- Tubers and roots (perishables; e.g., potatoes, onions, garlic); and
- Spices (e.g., dried chillies, coriander, and cumin seed).

About 90 percent of all products are imported from India, Europe, and Mediterranean countries. Direct delivery of these products is taken from the wharf, and the large stocks of pulses and grains are taken to the CWE wholesale outlets in Colombo.

Stocks are transported by truck from wharf to warehouse, where they are then stacked. The food products reach the consumer either through the cooperatives (Multipurpose Cooperative Societies) or through the CWE retail outlets--after a limited period of storage. A first-in, first-out procedure has been adopted to ensure that old stocks do not remain at the stores for a long time.

AREAS OF SIGNIFICANT LOSSES IN THE EXISTING SYSTEM

Field Losses of Rough Grain

Paddy

Harvesting. High labor demand during peak harvesting periods results in labor shortages, delaying harvest. Preharvest losses are often high. Timely harvest is an important factor contributing to both losses in quality and quantity. The time of harvest can precipitate shattering losses for different handling operations, losses due to birds, insects, and rodents, and losses at the final processing stage. The time of harvest also determines the quality of the rice grain. Prolonged exposure to high daytime and cool night temperatures causes internal cracking, commonly known as "sun checks."

Bundling. Handling losses due to shattering occur in the bundling of harvested paddy stalks for transport. Bundles may also be left on the ground for field drying. The duration of field drying and environmental conditions affect the quality.

Field Transportation. Losses in transportation are influenced by the method of field transport, the geographical terrain, nature of bundles, rate of transport, and the maturity of the stalk at transport. The highest losses occur in the transportation processes, although in some farming areas bundles are wrapped in mats to prevent grain from falling. This practice, however, is limited to very small land areas where family labor is involved in transportation.

Threshing. Threshing losses in both quality and quantity are influenced by variety, threshing method, the duration of field drying, and the maturity of the crops at harvest. The threshing method determines the percentage of cracked grains remaining after the threshing process. The duration of field drying and maturity of the crops at harvest and threshing determine the final milling output and percentage recovery.

Drying and Storage. Field stacking before the threshing operations is common in many areas. Losses have been observed in the stacking process where improper handling of the cut stalk results in the shattering of a large quantity of grain. Studies to determine the grain loss in this operation have not been made, although proposals to conduct such investigations have been submitted.

The stacking process occurs mainly to delay threshing until environmental and labor conditions are satisfactory. However, wet stalks stacked in this manner tend to deteriorate the grain quality with time. It is an assumption made by farmers that properly constructed stacks are watertight and survive under efficient storage conditions for 2 or 3 years. However, since studies have not been made on the stacking process, the losses resulting from storing grain on the stalk in stacks cannot be correctly assessed.

Field storage of grain is mainly in the farm-level storage structures commonly referred to as bissa. The storage is essentially for domestic consumption and seed. The major portion of the farmer's yield is sold either to the Paddy Marketing Board or private traders who buy the grain in the field. Farmers therefore do not consider storage on the farm to be important at present.

Coarse Grains, Grain Legumes, and Oil Products

The downward trend in production of these crops in the last few years is mainly due to inadequate marketing and storage facilities. The need for staggered harvesting of crops such as cowpea, green gram, and black gram results in fluctuating labor demands accompanied by storage demands at harvest. Storage of these legume crops is mainly in the farm level bissa and the grain is used for domestic consumption.

As stated above, timeliness in harvesting soybeans is extremely important. Soybeans lose their leaves when mature, exposing stems and pods for harvest. Varieties prone to shattering lose a greater percentage of the beans before harvest. Prolonged exposure to the weather also affects the germination rate. The common method of threshing (other than hand threshing) is to remove the bean by running a tractor over the whole plants piled on a threshing floor. A threshing-floor operation requires that soybean plants be cut, bundled, transported, and accumulated on the threshing floor. If any substantial amount of rain is received after the plants have been cut and before threshing is completed, the wet plant material presents an almost impossible drying problem,

resulting in moldy grains, useless for seed. Losses in seed quality resulting from weathering in standing bean plants are severe, but not nearly of the same magnitude as when the plants are cut, bundled, and laid on the ground.

FOOD LOSSES OFF THE FIELD

Grain Losses at the PMB

Grain losses incurred by the PMB during the operation of the GPS system are high (Table 6).

TABLE 6 Grain Losses Incurred by PMB

Year	Losses in Grain (1000 kg)
1975	450
1976	4,080
1977	4,540
1978	14,500 (includes cyclone damage)

Source: PMB statistics.

Grain loss occurs in many ways--as drying in storage; spoilage in handling and transport; natural deterioration; infestation; pilferage; attack by birds, rodents, and monkeys; and sprouting and germination. Although many of these problems could be prevented under controlled conditions, some can not. In grain marketing all over the world, a certain percentage is lost due to conditions beyond human control. The three common factors responsible for losses are:

- Moisture content at time of purchase;
- Length of storage; and
- Condition of storage and handling methods.

Traditionally, paddy was purchased by volume (bushel), and the moisture content did not play an important role in losses. But it is an important factor in the present-day purchase by weight. Although the stipulated moisture content at the time of purchase is 14.5 percent, the organization has thus far failed to adhere strictly to this optimum moisture content for a number of reasons:

- Inadequate equipment and supply of moisture meters;
- Lack of proper dockage system based on moisture content, which is a universally accepted factor in the grain industry; and
- Political interference and social factors.

As noted, the optimum moisture content is 14.5 percent. Nevertheless, the PMB officers purchase paddy with moisture content of 16-18 percent in many places, especially during peak purchase seasons.

High moisture paddy, when stored for long periods, develops "hot spots," which results in "caking up," lump formation, discoloration of grain, and decay. As a result, deterioration of paddy quality occurs.

Purchase of paddy is seasonal and 65 percent of the crop is purchased between March and June, while 18 percent is purchased between September and October. Imports make up the balance. Rice requirement of Sri Lanka is static at around 3 million bushels, while the peak purchase is around 4-6 million bushels. In many heavy purchasing areas, stocks must be kept in storage for a long time. The storage period varies from 4 to 7 months in some instances. Existing local conditions determine storage length, with stocks stored for long periods in particular stores, and others undergoing much shorter shelf life. In several instances stocks must be transported to other deficit areas for storage. This long storage period also may cause shrinkage, insect infestation, rodent damage, and bird damage.

Food Losses at the Food Department

A vast amount of grain is lost due to problems arising in storage and preservation. The main causes are insect infestation and attack by rodents and birds. A small percentage is also lost due to microfloral contamination. Although Sri Lanka aims for self-sufficiency through mass food production, the problems of storage and preservation have been completely neglected. The greatest problem faced by the Food Department (FD) stores is the infestation of grain with rice moth (Crosyra cephalonica) and capra beetle (Trogodarma granarium). The rice moth not only infests the grain but also causes serious problems, as it webs the rice. The rice then has to be cleaned even after fumigation. The capra beetle is also a serious pest, highly resistant to fumigants, and building its population in large numbers. Since the larvae of this insect leaves behind its cast-off skins, grain infested with this pest must be cleaned before consumption.

The FD also faces the problem of infested imported grain. Effective fumigation in the ship is the only solution to eliminating the introduction of new pests. Although some of the ships are fumigated by the port health authority, the dosage used is not sufficient to kill all stages of the grain pests present. Heavier dosage and longer period of exposure could successfully control this problem.

Food Losses at the Cooperative Wholesale Establishment

Pulses and Cereal Grains

When unloading takes place at the wharf, food losses occur due to spillage. The spillage is generally not sold to consumers but often used to manufacture animal feed.

Losses may occur during transport and stacking at the stores, but these losses are often negligible. Losses also occur when whole lentils are milled to obtain the split lentils known as dhal. The major losses take place during storage, especially if the food is stored for long periods. Due to lack of sufficient storage space and properly designed stores, insect infestation generally occurs. Often infestation is observed at the time these foods are unloaded at the wharf. Shrinkage, because of loss of moisture over a period of time, also occurs in the stores. Food losses from rodents and birds are also prevalent. Reinfestation of clean stock can occur if stored near infested stocks.

Remedial measures have frequently been taken. A fully equipped fumigation unit is in operation and fumigates insect-infested stocks. Every effort is made to prevent overcrowding of stores. Mold attack and subsequent deterioration or decay may also result in further losses. This may occur when stocks become wet at one stage or another.

Roots and Tubers

Food losses in roots and tubers are high. It has been observed that preliminary decay in onions and potatoes takes place when there is bad stacking aboard vessels transporting these foods. Poor aeration from closed hatches even during good sunny weather, contributes to the initial decay. Additional damage occurs at the wharf. With improper storing and stacking procedures, these perishable items do not last more than a week. However, the Cooperative Wholesale Establishment (CWE) takes necessary precautions to preserve these items after they are unloaded. Losses in roots and tubers due spillage at the wharf or during storage are low. Remedial measures adopted to minimize decay are to provide adequate aeration during storage and to avoid pressure from overloading the items, resulting in increased crushing and subsequent oozing. Rapid disposal is another remedial measure. Since the water content in this food category is high, loss in weight occurs to an appreciable extent even during the short period before it reaches the consumer. With fresh garlic and, to a lesser extent, smoked garlic, mold infestation during storage is common. Food losses then occur because mold-infested garlic is unfit for human consumption.

Spices

The Cooperative Wholesale Establishment imports spices such as cumin, fennel, and coriander in fairly large quantities. It also purchases locally such spices as pepper and mustard. Spices experience greater losses during unloading at the wharf than from insect infestation during storage. Storage losses are usually the result of moisture evaporation and loss of volatile oils. However, coriander is subject to insect infestation (Tribolium confusum) and requires fumigation with phosphine. In dried chillies, losses occur from spillage of seeds from broken pods and from mold infestation during long storage. Weight loss due to evaporation and mold infestation is high when chillies are under-dried. Bad storage conditions and stacking also contribute to the weight loss. Unsatisfactory storage conditions and improper design of stores result in rodent attack, which is fairly common on items such as dried chillies and coriander.

In general, food losses in Sri Lanka occur mainly from spillage at loading and unloading points, moisture evaporation during long or improper storage, rodent attack, and insect infestation during storage.

Losses also occur when food is contaminated by fertilizers, insecticides, mineral oils, etc. Such contamination may occur in hatches of vessels carrying these products.

FISH INDUSTRY

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INTRODUCTION

Sri Lanka's fishing industry expanded by leaps and bounds in the past 20 years as modern fishing techniques replaced traditional techniques (such as madel) and coastal fishing gradually was replaced by deep-sea fishing. These changes, and the consequent increased annual fish catch, were facilitated by mechanization and the increased use of nylon nets. Recently smaller fishing trawlers were introduced, and bigger trawlers of up to 80 feet in length are envisaged for the future.

From the moment the fish is taken from its natural environment until it is consumed hours, days, weeks, or even months later, there is a relentless and losing struggle against physical and chemical phenomena, which singly or in combination, eventually make the fish unacceptable as human food. Quality control in the fishing industry, or the war against spoilage, includes all the methods, procedures, and techniques employed to inhibit, delay, or prevent deteriorative changes in freshly killed fish and fish products, and to prevent contamination and adulteration. These measures cover the technology applied to the handling procedures, manufacture, storage, and distribution of fish and fish products to meet established or acceptable norms.

Surveys of present technology used to transport, store, and market fish in Sri Lanka indicate that there is room for vast improvement. Most of the small-scale fishing boats do not provide the necessary temporary storage facilities for the fish caught in the sea; therefore, fish are kept on the floor of the fishing boats. These poor handling techniques, coupled with the highly polluted beaches, high ambient temperature, shortage of ice, and the poor condition of the wooden boxes used in transporting, contribute greatly to the rapid spoilage of fish. The presence of bacteria, especially vibrio, has been detected in the surface and subsurface water off Sri Lanka's coast.

The sale of fish in Sri Lanka begins on the beach, immediately after the fish are unloaded from the boats. At this stage, fish are exposed to high temperatures and outside contaminations (e.g., flies). From this point, the inland wholesaler who operates at the market transports the fish to the retailer who sells the final product. The spoilage, which started at the beach or even from the fishing craft itself, increases rapidly due to the

poor transport system and continued exposure to high temperatures. In most cases the ice supply is very low and there is inadequate supply of pure water to wash the fish. Biochemical studies of the island's main marketing center, St. John's Fish Market, show a high degree of bacterial spoilage in the fish. This is mainly caused by the problems mentioned above, by the use of dirty fish boxes, and primarily by the custom of throwing fish about on the market floor.

The increase of bacterial growth during sales and distribution in Colombo has also been studied. For example, scientists know that fish transported from distant places such as Jaffna, Batticaloa, Mullaitivu, and Mannar to Colombo in lorries are poorly packed in wooden fish boxes and that the journey may take 12 hours or more. The ice used is inadequate to last the journey; hence spoilage is inevitable.

The quality of the raw material plays a vital role in determining the quality of the final product. The quality, which has deteriorated because of faulty handling at sea, cannot be restored by processing. Once the quality is lost, only low-grade food can be prepared by processing such as salting and smoking, which may partially mask the more obvious defects. Careful handling on board the vessel is vital; it is important to establish procedures for hygienic handling and to provide temporary storage facilities until the fish are finally delivered to the consumer.

Good-quality fish brought to the shore can become unfit before being sold or subject to any type of processing due to inadequate and improper handling. In assessing the problems of raw-material quality, a survey should be made at the landing point.

The trawler's capability to maintain good fish quality also must be reported. For example, the following aspects are directly related to the construction of the fishing boats:

- Insulation to inhibit heat transfer to fish holds;
- Suitable protection for the fish from sun, wind, and weather; and
- Use of impervious and easily cleaned material in the holds and other storage area.

The greatest drawback to maintaining fish quality on board the boats seems to be that the majority of Sri Lankan fishermen use traditional fishing boats that do not provide a power supply. However, this problem can be remedied to a certain extent if, within 6 hours of catching, the fish are brought to the shore and handled immediately to prevent further deterioration.

In Sri Lanka there is little application of fundamentals or technology of quality control in the fishing industry, from the fisherman through each link in the processing and distribution to the customers. However, a detailed survey is required to assess accurately the quality control problems existing in the fish industry and the failure to use the available technological information. Fresh, unspoiled, whole fish contain bacteria in the skin slime

and in the gut cavity and gills, while most flesh remains virtually sterile. Bacteria could be reduced by thorough and efficient washing, but most of the fish-unloading points do not have an adequate water supply.

The shortage of storage facilities in Sri Lanka also contributes to reducing the quality of fish products. Refrigerated storage for chilled fish or salted and other types of frozen fish, as well as low temperature storage of frozen fish, should be able to provide and maintain an optimum temperature environment. Proper storage facilities can also help control product contamination. Before launching a quality-control program, information must be collected regarding the availability of storage facilities and the effectiveness of the techniques.

The development of laws and regulations does not in itself assume a corresponding development of the industry, but regulations are necessary to protect the consumer by providing minimum quality standards and to protect the industry as a whole from acquiring an unfavorable public image. In the United Kingdom, the law permits the inspection of fish at port and inland markets by health inspectors.

POSTHARVEST TECHNOLOGY AND POSTHARVEST LOSSES IN THE FISH INDUSTRY

Postharvest technology, when practiced properly, is one of the most important factors ensuring effective use of fish and fishery products. As noted above, extensive losses in fish can occur at every stage from harvesting to consumption. The losses begin immediately after harvest on the boat because of the lack of facilities to preserve the catch until it is landed. The high environmental temperature (30° C) accelerates the enzymatic and bacterial spoilage of fish on board. The important losses are caused by enzymatic spoilage, insect infestation, and the beaches (highly contaminated with human feces and garbage) where the catch is landed and awaits auctioning and transportation to market by wholesale dealers. The primitive handling techniques, the inadequate preservation due to shortage of ice, and poor storage, transportation, and distribution systems also cause heavy losses.

The losses at harvesting also occur when the by-catch is dumped into the sea. Catching methods, fishing gear, and the fishing time are also responsible for losses because these can influence the quality of the catch (e.g., fish trapped in gill nets in tropical waters may start to spoil before they are lifted out of the water).

Nonutilization and underutilization of fish like silverbelly, catfish, carp, and tilapia must also be considered losses.

Postharvest losses occurring at all these stages in the fisheries industry could be broadly classified as follows:

- Physical losses (due to poor catching and handling methods);
- Biochemical losses (due to enzymatic spoilage); and
- Biological losses (due to bacterial, fungal, insect, and mite infestations).

The food losses that occur in wet fish, frozen fish, cured fish, under-utilized fish, and fish wastes in the artisanal fisheries industry in Sri Lanka are discussed below.

Wet Fish (Fresh Fish)

Fresh fish are preferred by consumers whenever and wherever available. Sea fish are widely eaten in coastal areas, while freshwater fish like tilapia and carp are more popular among the interior population. The city population prefers seer, paraw, and blood fish, especially among the upper-income brackets; those in the low-income brackets prefer rockfish and shore varieties. Shark and rockfish are more popular in the Mannar and Jaffna districts.

Handling and Processing

The type of boats used, including the traditional crafts, are not fully equipped to meet the handling and processing needs of the fishing industry. As noted, the traditional crafts do not have the space to carry ice on board and operation time is limited to unloading their catch on the beach. Even the modern fleet does not carry ice for icing the fish as soon as they are caught. The ice carried in larger prawn trawlers is used for high-priced items like prawns and lobsters. Hence, the other small pelagic fish varieties are most frequently subjected to loss. Ice is the cheapest, most convenient method for reducing the temperature to near 0° C and thus reducing spoilage. Therefore, good handling practices and the use of sufficient quantities of ice (at least ice:fish = 2:1) are necessary to keep the fish chilled. Good handling practices (sorting and washing) will reduce contamination and physical losses and provide speedy treatment of the catch before storage in ice.

Unfortunately, however, introducing use of ice to Sri Lankan fishermen poses several problems.

A large quantity of ice is required to reduce the temperature of fish, because the ambient temperature is rather high (30° C). This, plus the high cost and inadequate supply of ice are all reasons why ice is not used to preserve fish. Further, as noted above, the lack of pure water for washing purposes and for keeping good sanitary conditions aboard the handling vessels contributes to spoilage. The coastal waters and coastline are especially polluted.

The construction of fishing vessels to accommodate certain design specifications is also necessary. The design would accommodate sufficient

quantities of ice to be carried on the boat. The modernization of the traditional craft, the use of sufficient bacteria-free ice for preservation, and the use of good wooden boxes under hygienic and sanitary conditions is necessary to reduce postharvest losses of fish.

Transportation, Marketing, and Distribution

The sale of fish in Sri Lanka is in the hands of the wholesale dealer who sells fish on the beach. The inland wholesaler operating at the market transports this fish to the retailer who sells the fish to the consumer. Especially for the fresh fish industry--the ready availability of transport, refrigerated vans, and chilled storage rooms is necessary at various strategic centers including the wholesale and retail points. At present, the iced fish is packed badly in unhygienic, poor-quality fish boxes, with a capacity of 20 kg per box. They are stacked in lorries, covered or uncovered, and transported to urban areas.

Marketing at the Beach

Marketing starts at producing centers and takes different forms, depending on the location of the center. In sparsely populated areas or migrant fishing centers, the producer supplies his fish at arranged prices to a trader who operates a purchasing center at the beach. The producer is usually committed to a particular trader for his livelihood by a marketing advance and other facilities such as transport, rations, and temporary housing provided by the trader. In densely populated areas, the producer is more independent and negotiates a sale each day with several competing small-scale traders who gather at the landing points, or in some cases auctions are held on the beach or in auction sheds. Most of these collected fish are transported to the Colombo wholesale fish market and distributed to the retail shops. In Colombo and smaller towns, there are retail fish stalls in the public markets controlled by local authorities. Most of these retail stalls are in the hands of private traders. The Ceylon Fisheries Corporation (CFC) operates a number of purchasing centers and retail stalls in Colombo and other principal towns. Retail sales are also made by hawkers who take fish from house to house in baskets, pingoes, and cycles. The markup between producers' prices and retail prices in different parts of the country varies with area and species. Postharvest losses are due to poor displaying of fish on open tables and contamination with flies and to subjecting fish to high ambient temperature. Fish losses during this marketing process could be reduced by establishing properly made retail shops using good hygienic practices and having the facilities for chilled storage. The recently established retail shop of the Cey-Nor Development Foundation Ltd. in Colombo has incorporated these hygienic practices and technologies into its facility. Though the prices may be higher, a properly designed shop with good sanitary, chilled storage and displaying facilities would give the consumer a better-quality product while reducing the losses.

Frozen Fish and Other Frozen Fishery Products

Freezing fish is another way to reduce postharvest fish losses and, at the same time, supply fresh fish to consumers, although the capital investment is high for developing countries like Sri Lanka. Most of the fish caught are consumed in fresh form or processed into dried fish. Freezing and cold-storage facilities are mainly used by exporters (for shrimps, lobsters, and prawns) while the Ceylon Fisheries Corporation (CFC), (a public-sector organization) uses these facilities to maintain buffer stocks for contractual sales and for the production of packeted fish during periods of excess. Freezing is also done commercially by the CFC onboard their tuna long lines and by Cey-Nor Development Foundation Ltd.

The requirements of the importing countries, not only in terms of hygiene and microbiological requirements but also in terms of quality of the packs, are important. If these requirements are not met, heavy losses result from rejection of the consignments. The quality of raw material, quality control of the processing, temperature fluctuations in the freezers, and type of freezers to be used for the different kind of products, essentially influence the shelf life and quality of the frozen product. Freezer burn (drying during cold storage) and fluid loss cause weight loss and nutritional loss and also reduce the palatability of the product. The loss of nutrients, such as vitamins, minerals, proteins, and water-soluble amino acids occurs with the fluid loss, especially during the thawing of the frozen products. The plant sanitation, proper hygienic practice, routine microbiological analyses, maintenance of freezing plants and cold storage facilities, packaging, and transportation of frozen products in refrigerated containers to avoid temperature fluctuations are essential to reducing quality loss of frozen products.

Cured Fish Products

Locally Produced Dried Fish

About 90 percent of the domestic production of marine fish is consumed in fresh form, the other 10 percent being cured products. Processing consists mainly of salt drying, sun drying, or smoking, which is carried out without special facilities, on the beaches and backyards under very poor hygienic conditions.

The fish used for drying are mainly the small species found in the shore seine group. Most of the dried fish is produced in the districts of Mannar, Jaffna, and Puttalam as well as in the east coast districts. Local production of dried fish is about 25 percent of consumption; imports make up the balance.

The factors influencing the processing of dried fish are as follows:

- The price of wet fish;
- Availability of transport facilities and ice, or the fish are too low priced to support refrigerated storage;
- Degradation in the quality of fish;
- Fish that are not marketable as fresh fish and have less consumer demand due to their small size and mixture of species;
- Seasonal gluts of fish resulting from monsoon rains; and
- Species that fetch a higher market price as dried rather than fresh fish, e.g., katta (Chorenemus sp.).

Dried fish are one-third their fresh weight and must, therefore, be sold for at least 3 times the cost of fresh fish. Dried fish is eaten in areas where the fresh fish cannot be transported due to unavailability of transport facilities and during the off-seasons when the fish becomes expensive. Dried fish is also consumed in large quantities during the harvesting and ploughing seasons.

Only 40-70 percent of the original protein in fish may reach the consumer if the fish is dried; 25 percent is wasted during processing, storage, and long chain distribution. Losses in dried fish are more than with fresh or frozen fish.

Serious losses could occur with the processing of cured products. Each process and the resulting food loss is examined as follows:

Losses during initial processing. Good-quality initial raw material is needed to process better-quality dried fish and to reduce the losses that occur while processing spoiled fish. Also, in the course of dressing larger varieties of fish, losses occur because of fluid loss, as this fluid contains minerals and other nutrients as well as flavor.

Good-quality salt and chilled storage facilities for the fish are required at this step.

Losses during drying. The loss of liquid during drying also affects food quality. At present, the salted fish is dried at the landing places by spreading the fish on the sandy beach and on coir mats. The contamination of fish by sand and flies (dermestes and blowflies) occurs because most beaches are polluted with human feces because of limited public-sanitation facilities in these areas. The larvae of flies burrow into the flesh; the flies also are dangerous carriers of pathogenic organisms. Some losses are due to scavenger animals and birds. Damage is also caused during drying by shifting the fish at the end of the day, causing the fragile salted fish to break. Unsuitable weather conditions (rain, temperature, humidity) also cause losses. The use of properly designed drying racks and cemented drying yards and improved sun-drying techniques like solar dryers should be introduced to reduce losses during drying.

Drying by smoking is widely used for curing inland varieties like tilapia. The primitive method of smoking fish over a grid on an open fire may result in additional loss by charring or burning. There is also the risk of fire. Further, insect larvae can live in thick-bodied fish and are not destroyed by smoke; later, during storage, the maggots will destroy the product. Proper low-cost and simple smoking kilns should be introduced to obtain a better final product.

Losses during packing. The age-old tradition of using coconut palm leaf for packing locally produced dried fish is still the most popular method. This packing, containing 27 kg dried fish is called chippam. The disadvantages of this packing method are:

- It is not air tight;
- It is not waterproof;
- It is not insect proof;
- It breaks along corners; and
- Pilferage is easy and undetectable.

Sometimes jute hessian bags are used for packing dried fish. Damage could be incurred during packaging, e.g., in larger varieties of dried fish the bones and fins can pierce packing material and losses result from moisture reabsorption, insects, mites, infestation, and oxidation. The present method of packing should be improved to keep the dried fish dry, insect free, mold free, and uncontaminated. The disadvantage of the polythene used for packing is that sharp edges and hard dry points pierce through the thin film; insects also cut their way through polythene to attack dried fish. Therefore, a combination of polythene and wood or corrugated sheet boxes is better than polythene alone. These materials will withstand unsuitable weather conditions during packing and prevent damage during handling.

Losses during storage

Climatic conditions

When packed in the traditional method, dried fish is usually exposed to natural atmospheric conditions. It can be attacked by molds and bacteria, infested with insects and mites, and become rancid and discolored. This is much more prevalent in areas where the relative humidity is higher than 65 percent. Even though production is limited to the dry-zone districts, most of the dried fish is consumed in the wet zone, thus requiring storage time in the wet zone and in the retail outlets and wholesale depots. Most of these wholesale depots and storehouses are not properly designed to meet the storage requirements such as air improvements, ventilation, low temperature, and proper humidity.

The effect of molds and bacteria

Generally, locally produced dried fish are preferred over imported varieties and command higher prices because they are

dried and stored under better conditions in the production centers and may reach the customer within a few months of production. This is not the case with the imported varieties where there is a 15-percent surcharge upon landing at Colombo; occasionally entire shipments are rejected because of poor quality.

The high moisture content of the dried fish, particularly imported varieties, and the salt used for processing, allows molds and fungi to grow in them. The most common fungus, white in color, grows on the surface of the dried fish. In those dried with excessive salt, a red halophilic bacterium (Sarcina sp.) is found, changing the color of the dried fish to pink or dull red. This bacteria is a contaminant of the salt if the salt used is not clean and dry.

Insect infestations

Two or three types of insects and several species of mites are commonly found in dried fish of poor quality. They are well adapted to the salty environment. Larvae of these insects cause heavy damage to dried fish by eating the flesh, resulting in high economic losses. Insect infestation could be reduced by use of proper sanitary methods, proper packaging, and by use of chemicals like pyrethrum. Irradiation of fish to kill maggots, larvae, and flies is not practical, because of the high capital cost of sophisticated technology and the numerous, small centers where fish are cured and sold.

Contamination often occurs unless care is taken to avoid placing poor-quality material on top of good-quality material. Salt drip and moisture drip from above will spoil the good-quality products and lead to heavy losses. The large storehouses for dried fish must be kept clean and well ventilated. The packs should be constantly checked for quality. In the areas where relative humidity is rather high, dried fish must frequently be redried in the sun to avoid leaching and rehydration; in these areas, dehumidified rooms for storing dried fish should be provided.

Imported Dried Fish Industry in Sri Lanka

Dried fish has been imported to Sri Lanka since the early 19th century. Until recently, the monopoly on imported dried and canned fish was held by the Cooperative Wholesale Establishment (CWE). At present, the dried fish is being supplied from India, Maldives, Pakistan, and Singapore.

Dried fish from Tuticorin. Generally, dried fish are freighted in sailboats. The cargo in the hatch is crowded, overstacked, and poorly ventilated. However, under normal sailing conditions, a boat reaches the Colombo port in 4 days. Sometimes when the seas are rough and stormy the shipments are delayed, in which case the condition of the commodity at the time of landing is very poor. The situation is worse, particularly during the monsoon season, when there is a tendency by the shippers to export underdried fish. Pakistan supplies arrive by ships that are supposed to be well-ventilated. However, it generally takes about 14 days for the ships to

collect dried fish when the supplies come from different parts of Pakistan. The ports in Pakistan, with the exception of Karachi, are not geared with proper loading facilities. In these ports, the ships are anchored in mid sea and the goods are transported in small boats to the ship. These delays are a big threat to the quality of dried fish. A preliminary study on dried fish trade conducted by Dr. N. N. de Silva, who was at the Fisheries Research Station prior to 1966, revealed that there had been a tendency for the shippers to dispatch underdried fish. The fish were purchased by weight, which meant that foreign exchange was being spent on water. Additional losses occurred because improperly dried fish tended to spoil. This problem was minimized considerably after the imposition of standards and regular checks of the samples of the imported dried fish by the quality control laboratory, which was founded in 1968.

Dried fish shipments as well as other bulk-food cargo are inspected on board by a quality control officer of the CWE and the port health officer to ascertain that the cargo has been safely stored away from any possible contamination. The shipment is normally discharged directly into lorries and transported to the retail stores at Welisara. The direct discharging has many advantages; for example, it cuts off the retention time in the port, thereby minimizing damage due to crushing, and it reduces pilferage in the port.

At Welisara, after receipt, each shipment is sorted out according to each shipper's mark and kept in rows according to each variety under the same shipper. Each bag is cut open and examined by a grading officer. Normally, at the time of grading a representative is present from the shipper's local agent. Poor-quality fish are pulled out of the bag and, depending on the quality of the fish, a quality cut is made. If the bag contains mostly bad fish, it is totally condemned.

The grading officers have a fair knowledge of the varieties of fish although they are not technically trained. A staff officer who is experienced in sorting and grading oversees their work. After identification of the variety in the bag, the fish are graded as good, acceptable, but with a quality cut depending on the physical appearance, or rejected as totally damaged, according to the smell, texture and appearance. They are regularly guided by the quality control officers who explain the scientific basis for evaluating the fish. Samples are drawn and tested to check the performances of the grading officers.

After grading, the dried fish is stacked in the godowns, usually seven bags high. The godowns are large, humid, and usually have no exhaust or artificial ventilators. Since some of the dried fish have high moisture content and the temperature is also high, uneven condensation of moisture occurs, and after some time the dried fish become soft and emanate an unpleasant smell. Graders generally request that the dried fish be rebaked if the odor is too strong. With long storage, a red salt bacteria develops, which changes the appearance of dried fish. This is most common with shark. When dried fish arrives with insect infestation, it is fumigated with Phostoxin.

Another problem with storage occurs when the fish is very oily (a seasonal condition). This also makes the fish soft and bad smelling. However, with all the precautions taken in cleaning shipments early, minimizing handling, providing better storage facilities, and quick disposal, the loss of imported fish by condemnation has been emphatically lessened. Nearly 2 percent of the imported fish were condemned in 1978. This represented a loss of over 1.6 million rupees.

Unutilized and Underutilized Fish and Fishery Products

Food processing technologies can add a new dimension to Sri Lanka's fish industry by utilizing various species of fish which, though plentiful, are presently unacceptable or undesirable for human consumption. The primary unexploited resource seems to be the by-catch from shrimp trawling. The major problems with handling this by-catch arise from the variable mixture of species (small shark, rays, and small bony species like silverbelly). Although silverbelly represents the bulk of the catch in Sri Lanka, their small size, bony structure, and rapid oxidation and spoilage make them unpopular. Silverbelly and other varieties are not only unprofitable to ice and bring ashore, but their quantity varies widely from catch to catch. For example, sometimes the shrimp to by-catch ratio varies from 4 to 20 times. Moreover, the fishing boats are not designed to handle this by-catch economically. While the method of processing by-catch at sea has the best potential for profitability, for this purpose the boat size must be increased. However, marginal profitability can be obtained by landing these by-catch and processing them into other fishery by-products like fish protein concentrate (FPC), fish meal, or fertilizer.

The new technology of meat-bone separators has increased significantly the utilization of by-catch for human consumption. Latent fish resources such as krill, squilla, and mesopelagic fish species (e.g., lantern fish) have great potential as an alternative food source if harvesting and processing technologies can be developed and successfully employed. Waste fish and unexploited, unconventional food resources can be used to manufacture fish meal, which is important for animal husbandry and aquaculture. Sri Lanka's few inefficient fish meal plants now operate at a relative economic loss. However, the fish silage process--a low-cost method with simple technology--could be used for animal feed preparation, and silage could be introduced into larger vessels for onboard preparation.

Some freshwater fish species like tilapia have a muddy flavor and are not very popular among the city population. However, these fish could be used to prepare fish products in which the flavor is masked through various food-processing techniques. The steps already taken by the Institute of Fish Technology (IFT) to increase the use of less desirable fish for human consumption will certainly help reduce postharvest losses due to underutilization. The fishery products prepared at IFT, using tilapia and other marine by-catch like silverbelly and catfish, are fish sausages, fish fillets, fish biscuits, fish floss and balls, fish cake, fish paste, and fish crackers. Consumer acceptance of these products is fairly good.

Waste Utilization

The postharvest losses of fish could be greatly reduced by full utilization of the whole fish, but only the FPC can be prepared directly for human consumption using whole fish. The other processing wastes like fish offal, prawn waste, and spoiled fish could be converted to animal feed through fish-meal processing or by preparing fish silage. The guts, entrails, trimmings, skins, fins, bones, and gills are the common fish wastes available for this purpose. The IFT has introduced a low-cost, village-level fish-meal plant to convert fish offal and waste fish into fish meal. Prawn waste consists of about 60 percent of the whole shrimp and prawns. Hence, prawn waste is also a good raw material for animal feed production. The other fishery by-products from fish and prawn waste that could be exported are shark fins, shark skins, and chitin from prawn skeletons. The IFT has developed techniques to process these products which will also help indirectly to minimize postharvest losses.

MEASURES ADOPTED BY THE MINISTRY OF FISHERIES

To meet the increasing demand for fish, the Ministry of Fisheries has prepared a master plan (1978-1983). The major objective of the plan is to increase the total catch from 160,000 tons in 1978 to 250,000 tons in 1983. To achieve this objective the plan has taken into account the present shortcomings in the fish industry from harvesting to the retail stage. The plan will also emphasize the construction of fishing boats designed to meet present needs and shortcomings so that the boats can accommodate sufficient quantities of ice for purposes of preservation. The Ministry of Fisheries has prepared a program of public-sector investments in ice plants and cold-storage facilities to fill the present gap between demand and private-sector supplies and to provide tax incentives to the private sector. In particular, the Ministry is promoting both state and private-sector investments in ice plants and cold-storage units to meet present needs as well as provide for the planned increase. These range from inexpensive insulated units at the beaches to cold-storage complexes in major producing districts. Cold storage is also planned in strategic locations in the consumer areas in the hinterland to enable more efficient retail distribution of fresh wet fish. Freezing as well as distribution of frozen fish will only be undertaken as a last resort during glut. The Ministry of Fisheries is also taking action to maintain fair prices to the fishermen, while at the same time ensuring a more regular supply of fish at reasonable prices to the consumer. The following steps are planned:

- Instituting auctions wherever feasible;
- Providing sufficient ice and cold storage at the point of landing and sales;
- Increasing purchases by the Ceylon Fisheries Corporation, especially the accumulation of buffer stocks during the peak fishing seasons;
- Initiating product-development research to process the

substantially increased quality of low-priced and unpopular species of fish; and
- Encouraging and educating the fishermen to improve the methods of handling fish and to improve the quality of fish products.

It has been estimated that in 1978 the supply of fish for fish storage and transport was about 60,000 tons, while the demand was 70,000 tons. There were also shortfalls in freezing, cold-storage capacity, and transport. This shortfall caused fish wastage and poor quality fish. The remoteness of many fish-landing centers, the fluctuating nature of fish landing, and operational difficulties arising from a lack of good water and electricity supply in some areas make investments more risky and less attractive to private investors. Thus the government has been given a major role in this investment program. In the handling and processing of fish the Ministry of Fisheries has a program designed to do the following:

- Improve handling of the catch on board vessels, including gutting, cleaning, and the use of ice (there can be spoilage even in the water due to the time lag between actual catching and collection on board);
- Improve handling of the catch at landing points with the supply of ice storage and other facilities;
- Improve methods of wholesaling and retailing fish, which includes improved designs of fish boxes and stalls and better handling during transportation;
- Upgrade the production of dried fish involving the provision of adequate facilities for drying and landing points, both in marine and inland fishing areas, while improving techniques of sun drying to prevent waste and spoilage; and
- Develop new products for human consumption from unutilized and underutilized edible species, an objective that has been assumed by the IFT of the Ministry of Fisheries. (It is hoped that fish paste, sausages, cakes, and fillets as well as fish powder and fish biscuits will be made available in the near future).

ROLE OF THE INSTITUTE OF FISH TECHNOLOGY

It is important to note that the FAO/SIDA Institute of Fish Technology (IFT) of the Ministry of Fisheries was established to reduce postharvest losses in Sri Lanka's fisheries industry. Estimates for annual fish losses range from 20-30 percent but could be reduced to 5 percent with the introduction of proper handling, preservation, storage, distribution, transportation and retailing methods. The IFT started functioning in 1978 and has helped reduce Sri Lanka's postharvest fish losses by introducing various methods for preservation and transportation under chilled conditions and by designing a new, more hygienic fish box.

Particular attention has been paid to the processing of shrimp, lobsters, and cuttlefish by educating the processors on the requirements of quality packaging under hygienic conditions with microbiological control. The IFT has conducted a training course in sanitary prawn processing for workers and staff. The Institute has also carried out microbiological analysis of their frozen products and has developed a number of processes for the various aspects of harvesting, handling, preservation, storage, distribution, and retail sales. Although the Institute has been concerned with quality control of the shrimps and prawns that are exported, the facilities available for microbiological control at the Institute's laboratories are inadequate for regular inspections and tests. The Ministry of Fisheries is initiating programs for regular inspection and quality control of the various fish and fish products that are being consumed and exported.

RECOMMENDATIONS

Several suggestions have been underscored repeatedly in this report as necessary for reducing postharvest losses. These include adequate ports and harbors; upgraded roads to the landing centers for quicker transportation; improved public sanitary facilities, houses, and sewage disposal; storage premises; and fresh water supply (apart from the subsidies and credit facilities for the fishermen which are inherent in a developing economy). Therefore, the major recommendations are as follows:

1. Improve handling of the catch on board boats, including gutting, cleaning, and the use of ice. Spoilage can occur in the water due to a time lag between actual catching and collection on board.

2. Improve handling of the catch at landing points, with the supply of ice storage and other facilities.

3. Improve methods of wholesaling and retailing fish, which includes improved designs of fish boxes and stalls for wholesaling and retailing and better handling during transportation.

4. Improve the production of dried fish by providing adequate facilities for drying at landing points, both in marine and inland fishing areas, while improving techniques of sun drying to prevent waste and spoilage.

5. Initiate product development research for human consumption to process the substantially increased quality of low-priced and unpopular species of fish.

6. Encourage and educate the fishermen to improve their methods of handling fish and thereby improve the quality of fish products.

7. Formulate standards and codes of practices for handling of fish and enforce these standards through required training facilities for fishermen and provide testing facilities.

POSTHARVEST FOOD LOSSES: A CALL FOR ACTION

N.S. Agrawal

An impressive array of general knowledge has flown from gentlemen scientist elites who have seldom been to problem locations except on ceremonious occasions. Hence there is more noise in the seminars, workshops, and conferences than action, and that noise from only those whose voice dies out in the cathedrals of bureaucracy. Experts talking to experts is meaningless and nothing more than classroom talk. The dialogue would be more meaningful between experts and bureaucrats. Until they realize the gravity of the situation and provide adequate personnel and material to grapple with the problem, with due participation of the farmers, nothing tangible can be achieved.

In 1975 Jean Mayer, the distinguished nutritionist, wrote a timely article entitled "Agriculture: The Island Empire." He pointed out that most of the decision makers in policies and resource allocation have neither background in, nor appreciation for, agriculture and its problems except when food prices rise or there is a shortage of food grains, famine, or other predicaments.

Agricultural scientists have not been held in the highest regard and there has often been a credibility gap because they have failed until now to make their voices heard among those who determine policies. Policies for storage face a series of contradictions. Food is a necessity of life, but little money can be spent for protection of the basic foods and cheap commodities. The decision must be made whether to spare capital on storage structures that could remove most of the risks of grain storage and to embark on a regular program of preventive and control measures, or to spend nothing except on emergency measures and otherwise accept losses in storage. The major storage problem is that the natural losses are highest where they can least be afforded, i.e., among farmers in the tropics and subtropics. For small-scale storage the risks are considerably greater, and examples of exceptionally heavy losses are encountered regularly. It is here that policy problems are especially difficult. The farmer himself may not be able to adopt scientific methods of storage advocated by the experts until he is persuaded that these methods are better if not cheaper than his. This would require a massive effort over a long period of time.

Much more is known about grain storage than is being practiced. Even

after two decades of growing concern, only very recently has the problem been brought into focus. Why? In the past more attention and assistance on renewable natural resources was given in the preharvest production sector. Second, the nature of damage suffered by food grains did not require urgent action. The damage is done silently in an unspectacular manner. Third, those developing countries suffering a chronic shortage of food grains could import them on easy terms. Fourth, the people could not raise their voices to tell the authorities that they do not want to eat filthy insect-ridden and rodent-contaminated grains in times of shortages. Finally, there is a shocking lack of appreciation of the size of the problem worldwide and a thorough lack of education about postharvest technology, with a resulting shortage of suitably trained personnel. Special knowledge and skills are required in handling, storage, preservation, maintenance of stored products, and control of insects, and rodents. In most developing countries this responsibility is given to whomever is available. At times trained personnel are available, but there is never enough material to carry on the work effectively, and vice versa.

It is strongly recommended that the roles of scientists, technologists, sociologists, economists, and administrators be integrated. Scientific studies alone are not enough. As mentioned above, there is no dearth of knowledge on the subject; it is only its application that is lacking. Man is the central figure who can bring about change and for whom the resultant benefits are intended. It is therefore essential to consider and reconsider the significance of the various habits and customs of local communities as the main environment within which technological innovations must be applied. Awareness, understanding, ability, implementation, assessment, and appreciation of benefits are human attributes and these will emanate from a balanced development program. It is essential to create a national infrastructure by which existing information, however simple, is brought to the attention of the farmers and the traders so that changes in grain storage and handling practices become an integral part of farming and trading.

Prevention of losses must be attempted by ensuring that farmers, agricultural extension staff, cooperative personnel, traders, administrators, and community welfare workers generally realize the importance of their work and appreciate the advantages that will accrue in terms of economic betterment and their well-being as a whole. This requires within each country a cadre of trained personnel with responsible positions in the government through whom farming communities would be encouraged and eventually forced to introduce improved methods of grain handling and storage.

Integrated development to minimize losses to harvested crops is still inadequate. There are a few loose links between research and extension: the extension people are barely concerned or they do not incorporate postharvest problems in their duties; extension workers render little if any advisory services to the farmers in the marketing centers to help them get the highest price for their produce; and hardly any communication exists between agriculturists, inspectors, and other village or community developmental workers or officers. Thus, postharvest activities at present remain neglected.

Several authors in the past have described exhaustively the biology of stored-grain insect pests, rodents, fungi, the losses caused by them, and how to control them. Therefore, it will simply be repetitious to append an annotated list of insects and their control measures, etc. The problems of environment, climate, moisture, and humidity have been studied in detail and have been reported extensively in the literature. It has been emphasized that grain is a living entity and must be looked after properly. The carelessness, apathy, and indifference of man to follow recommended practices are mainly responsible for the colossal waste of food grains and other foodstuffs in storage. This waste is avoidable and, with a little effort, can be arrested.

It is now well known that mycotoxicoses are diseases of men and animals caused by consumption of food made toxic by fungi. Livestock such as pigs, horses, and poultry are more sensitive to moldy grains, and several incidents of liver damage have been reported from Africa, India, and Southeast Asia. Nevertheless, not enough has been done to improve storage methods, which alone are responsible for these maladies.

The emphasis on increased production of food grain in the over-populated and undernourished countries of the world is, of course, laudable and essential, even though at times it seems to be leading to more people who need more food to produce more people. Increased production of food alone is not sufficient; the developing countries want and need not only more food but more wholesome food, and especially a greater variety of nourishing protein foods. Improved quality of food is as important as increased quantity. Programs to increase food production must emphasize higher quality, since most of the mycotoxins now known are produced by fungi that grow on poor quality produce. Improved storage methods of food products are essential in all places where grains, seeds, feeds, and foods are stored. Action to arrest deterioration in quantity and quality should start at the farmer's house. No amount of corrective action later on during storage processing, handling, etc., will undo the damage already done to the produce.